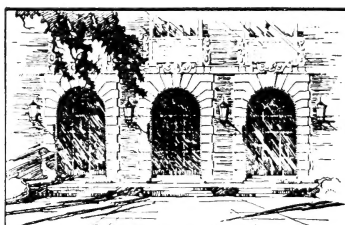


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*State Laboratory, Report
Second*

REPORT

OF THE

DIRECTOR

OF THE

STATE LABORATORY OF NATURAL HISTORY,

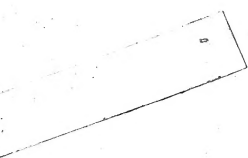
NORMAL, ILLINOIS,

FOR THE YEAR ENDING JUNE 30, 1880.

SPRINGFIELD, ILL :

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REPORT OF THE DIRECTOR OF THE STATE LABORATORY OF NATURAL HISTORY.

HON. JAMES P. SLADE, *State Supt. of Public Instruction, and Secretary
of the State Board of Education, Springfield, Ill.:*

SIR—The operations of the State Laboratory of Natural History are now included under the following heads: By the law of 1877, establishing a State Museum, the laboratory was charged with providing for that institution, as soon as possible, a series of the plants and animals of the State, and an appropriation of \$1,000 per annum was made for that purpose. This appropriation was repeated in the same terms at the last session of the State legislature. The laboratory was also required by the above law to furnish, as far as practicable, all zoölogical and botanical matter needed by the State educational institutions for the proper performance of their work; but no appropriation being made at the time for that purpose, but little could be done, at first, in that direction. This omission was corrected at the last session of the legislature, \$250 per annum being appropriated for this purpose, and the supply of these institutions has, therefore, become a regular part of the work of the establishment. An appropriation of \$250 per annum was also voted to the laboratory, at the last session, for the supply of public high schools, thus necessitating the preparation of illustrative cabinets for distribution. We were also directed to investigate the large and intricate subject of the food of birds, in the interests of agriculture and horticulture, \$200 per annum being voted for the expenses of this work. A similar research was directed, and provided for, respecting the food and habits of fishes—a subject of vital importance to fish culture, and one upon which very little accurate information has been hitherto accumulated. The sum of \$150 per annum was voted for this purpose. The remaining appropriations of the bill under which we are now working, are \$1,100 per annum for additions to the library, \$250 per annum for the publication of bulletins, and \$800 per annum for the pay of an assistant. It will be seen that the operations of the laboratory may be conveniently and accurately described as constituting a zoölogical and botanical survey of the State, conducted with reference to its scientific, educational and economical interests. Although not formally so termed in the laws relating to the institution, this is what those laws necessarily result in, when their directions are carried out; and this is the point of view which I shall take in reporting on our work.

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FIELD WORK.

In arranging the field work, I took into principal consideration the needs of the State Museum, making the collections for other purposes subordinate to those of this institution, but so locating our operations as to cover parts of the State not previously worked over, in order to make the survey of our natural history as nearly complete as the conditions of the work would allow. Besides almost continuous collecting going on in the vicinity of the laboratory, several trips have been made to more distant points. The first of these, after the present appropriations became available, was made to the Fox and Illinois rivers, at Ottawa and Peru, in July, 1879, at the time of the field meeting of the State Natural History Society. Four assistants accompanied me on that trip, which resulted in fair additions to the collections of fishes, especially of the young of numerous species, taken for the study of their food; and a very good collection of fishes' stomachs, together with a good deal of miscellaneous material.

The second trip was taken in August to extreme Southern Illinois, with two assistants. We established ourselves on the south bank of the Ohio, opposite Cairo, and worked steadily for nearly three weeks in the Ohio and Mississippi, and in the lakes and small streams in the country adjacent to those rivers. Large numbers of duplicates of the common fishes of that region were preserved in alcohol for the State Museum and State educational institutions and the public schools. A good set of fish skeletons and a few skeletons of birds were obtained for the museum; collections of material for the study of the food of fishes and birds were made, and especially good collections of mollusks and insects. On our return from this trip, one of my assistants was sent to Spring Lake, in Peoria county, where, by working with the fishermen, he secured a sufficient number of such fishes as we found scarce in Southern Illinois; and continued, with success, the various kinds of field work above mentioned. Casts of nine different species were secured on this expedition, for the State Museum at Springfield. An assistant was sent, during the months of July and August, to the western part of the State, near Quincy, to collect the leaf-blight and other fungi of that region. He also collected, in the same department, during the remainder of the summer at Normal, and added about 250 species of these plants to the herbarium, besides a small set of flowering plants and several hundred specimens of insects. In the spring of 1880, the principal expedition undertaken crossed the northern part of the State, from Galena to the valley of the Fox river, and thence northward to the lake region of Lake and McHenry counties. Three weeks were occupied by this trip, and large collections were made from the streams of the hilly regions of northwestern Illinois, from numerous tributaries, large and small, of Rock river, to the east and west, and from Fox river and its tributaries, and from the lakes in which this stream principally takes its rise. Additional collections were made from the country traversed, especial attention being paid to birds and insects. The success of the trip was unusual, and many thousand specimens were accumulated by this three weeks' work. Later in July, a trip was made to Lake George, Indiana, just across the line of the State, upon the occasion of the

summer meeting of the State Natural History Society, and a week was spent chiefly in making collections of insects, fishes and other aquatic material from this region. Large collections of fungi and of flowering plants have also been made during the past summer, by Mr. John Wolf, of Canton, Illinois, and a fine collection of the seeds and fruits of the flowering plants of the State, numbering some 600 species, has been made for us by Dr. F. Brendel, of Peoria.

During the two years preceding the period covered by this report, four-fifths of the species of the birds of the State, as shown by Mr. Ridgway's list of Illinois birds, published in 1876, had been furnished us for the museum by Mr. C. K. Worthen, of Warsaw, and the contract with him was continued for the remaining fifth. These birds have all been sent in, and the collection now contains good specimens of all species known to occur in Illinois at that date.

LABORATORY WORK.

It is impossible to make a full report of the laboratory operations at this time, because the work of determination, arrangement and distribution is still in progress. While a part of the results can be given in detail, others can only be described in general terms.

STATE MUSEUM.

We have furnished to the State Museum, during the last year, 15 mounted specimens of mammals, representing 12 families, and including a buffalo, an elk, a wolverine, a badger, an ornithorhynchus, and several smaller animals. Except a few especially interesting forms, we have not attempted to go outside the fauna of the State, either present or past. Besides the birds already furnished through Mr. Worthen, we have sent down a pair of mounted peacocks for the museum collection. The series of painted casts of the fishes of the State, made at the laboratory for the State Museum, now represents 38 species. We have, besides these, 6 molds of which casts have not yet been made, and 56 oil sketches of as many different species, from which the casts already furnished have been colored. These paintings, with the casts in the museum and the alcoholic specimens at the laboratory, furnish the material for an elaborate illustrated work upon the fishes of the State, which can be prepared at any time. I believe that it is the general testimony that, for accuracy and beauty, these fish casts have not been surpassed anywhere in this country.

We have now in hand for the museum about 100 species of alcoholic fishes from Illinois, representing 20 families, and alcoholic specimens of 28 species of other vertebrates. We have also prepared and mounted and sent to the museum 31 skeletons of animals—4 of them being mammals, 7 birds, 5 reptiles, 1 an amphibian, and 14 fishes. The plan of this work is to prepare a good mounted skeleton to illustrate each order of the higher vertebrates of the State and each sub-order of fishes. We have improved the opportunity to secure for the laboratory an excellent series of disarticulated skeletons of fishes, which, when completed, will represent

each Illinois genus. The insects contributed to the museum, collected during the past year, amount to 1,375 specimens, belonging to 720 species, 447 genera and 102 families. These specimens were all collected within the State by my assistants. They have been labeled both with name and locality, and regularly arranged, so that they require only to be transferred to the museum drawers, whenever these shall be provided. We have also prepared and sent to Springfield (all mounted and properly labeled) 750 species of the flowering plants of Illinois, and have now finished the preparation of about 300 species more. A full series of our cryptogams, most of which have been named by Prof. Peck, of the New York State Museum, will be sent to Springfield as soon as the work upon them now in progress can be completed. It is impossible at the present time to give more than a very loose estimate of the number of species contained in this collection, but they probably cannot fall short of 500 species.

STATE EDUCATIONAL INSTITUTIONS.

The law requires the State Laboratory of Natural History to furnish, as far as practicable, all zoölogical and botanical material needed by the State educational institutions for the proper performance of their work. By the term "State educational institutions," we have thus far understood the two Normal Universities and the Industrial University at Champaign. The amount appropriated for this purpose was too small to permit special expeditions for the supply of these institutions, and it has seemed that it could be most profitably used by merely collecting additional amounts of such material as the general operations of the laboratory made it possible for us to secure. As the specimens accumulated for this purpose have not yet been fully worked up, I can only estimate their numbers. We shall be able to send to the Industrial University at Champaign, and to the Southern Illinois Normal School, at least 75 species of alcoholic fishes and several hundred species of phaenogamic and cryptogamic plants. To the former of these institutions we can also furnish about 700 species of insects. That part of the appropriation for the supply of the State educational institutions which properly belongs to the Normal University at Normal, has been used chiefly for the purpose of completing the collection of bird skins for the use of students, and for the supply of material for dissection by the classes in zoölogy.

PUBLIC HIGH SCHOOLS.

We have used every opportunity for the accumulation of material for the public high schools, and have secured many thousand specimens for this use. The appropriation was only sufficient to enable us to linger a little longer at the best localities for collecting, or to engage, now and then, a little additional assistance. No purchases have been made, and no special trips have been undertaken for this purpose. The work on the material collected is still in progress, and accurate numbers cannot be given at present. We shall certainly be able, however, to distribute this winter 30 sets of specimens of fishes, insects, and crustaceans and marine

vertebrates. The fishes will represent from 60 to 70 species of 17 families, and the insects about 300 species, belonging to 100 families of all orders but the diptera. In order that this material might be bestowed where most needed, and where we could be assured that it would be properly used and cared for, I sent the following circular to the 111 schools on the list of public high schools furnished me from your office:

ILLINOIS STATE LABORATORY OF NATURAL HISTORY,
NORMAL, ILLINOIS, 1st September, 1880.

DEAR SIR: In order that the zoölogical material furnished by this institution to public high schools may be intelligently and impartially distributed, replies to the following inquiries are respectfully requested:

1. Is zoölogy one of the regular studies of your high school course?
2. How many weeks' work is required in this branch?
3. What is the average number of students pursuing this study in your high school?
4. What material have you already for the illustration of the work of your classes?

(Answer by filling the blanks below.)

	Number of Species.		Number of Families represented.	Number of Orders.	Number of Classes.
	In alcohol.	Dry.			
Fishes.....					
Insects.....					
Crustaceans.....					
Marine Invertebr'ts.....					

5. What cabinets and cases have you for the protection and arrangement of specimens in zoölogy? Square feet of open shelving? Of shelving behind doors?... .. Of open drawers?..... Of covered drawers?..... Of covered trays?.....

6. Will your board of education provide for the care and use of alcoholic specimens of fishes, crustaceans and marine invertebrates, and pinned specimens of insects?

An early reply to these questions will greatly facilitate the work of distribution.

Very respectfully, yours,

S. A. FORBES,

Director of Laboratory.

Replies to this circular have been received from fifty-eight schools, and a summary of the details thus accumulated is given herewith. It is of special interest as showing the condition of the schools with reference to the successful and intelligent teaching of the elements of natural science:

SUMMARY OF REPLIES TO CIRCULAR.

	Wks in course.	Pupils.....	Fishes.....	Insects.....	Crustaceans...	Marine invertebrates.	Open shelves..	Enclosed shelves....	Open drawers.	Covered drawers....	Covered trays.
Amboy.....	16	15						10			
Bloomington.....	20	50		136	8	9		35			
Bushnell.....	32	14									
Canton.....	12	20									
Carrollton.....	24	12	7	186	21	27		124			30
Centralia.....	18	15						48			
Charleston.....	20	12						75			
Chicago.....	24	104								24	
Chicago.....	16	200									
Clinton.....	16	13						50			
Danville.....											
Decatur.....	15	30	*	*	*	*	Well	sup	plied		
Dixon.....	15	7						15			
Durand.....	20	10					50	50			
Dwight.....	16	10						30			
Elmwood.....	12	8						80			
Evanston.....	16	25						30			
Fairbury.....	16	15									
Farmington.....	16	12						24			
Galesburg.....	16	30	*		2						
Geneseo.....	16	40									
Griggsville.....	16	8									
Greenfield.....	24	14									
Jacksonville.....	16	30	1	1				40		6	
Lake View.....	20	20	2		4	5		100		160	
Lewiston.....	12	10		200				80	27	12	
Lexington.....	14	20									
Lockport.....	16	9		50							
Marengo.....	11	15						16		6	
Moline.....	20	15	1	75	2	3		65		8	
Monticello.....	22	18		50	1			10		6	
Morris.....			1					500			
Morrison.....	20	20			2	2		54			
Mt. Sterling.....	14	12					84				
Oak Park.....	12	10				17	18	84	28	8	
Odell.....	12	8									
Oregon.....	40	15	12				2000	1500	86	20	
Ottawa.....	12	36					120	900			
Peru.....	24	25	150	100	120	2		25			
Pontiac.....				20	5			100			
Princeton.....	12	55					30	55			
Quincy.....	32	40					20	8			
Rock Island.....	16	19									
Rochelle.....	12	20	7	*	1			50			
Rushville.....	17	15	3	115	30		20	29			
Rockford.....	32	90					250	350		25	
Sandwich.....								36			
Sheffield.....	30	15									
Sterling.....	20	12							20	24	
Streator.....	26	25					50	100		80	
Tuscola.....	16	20									
Urbana.....	16	10					Well	sup	plied		
Vandalia.....	16	10									
Washington.....	35	6									
Whitehall.....	16	12						6			
Woodstock.....	26	17	5	100	3		150	100			
.....	+13	65						200	50	25	
.....	+16	12									

*A good collection.

+Circulars returned without signature, address, or legible postmark.

Four of the schools reporting made no mention either of the time included in the course or the number of students pursuing it, and it is therefore presumed that zoölogy was not taught in these schools. In every case the promise was made that whatever material should be contributed would be properly provided for.

The average time allotted to the study of zoölogy in the courses of these schools was 19 weeks, the longest time being 32 weeks, and the shortest 10. The total number of pupils pursuing the study of zoölogy in 54 schools was 1,312, giving an average of 23 to each school. The total number of specimens of fishes in these 58 schools was 190, averaging a little less than 4 to each school, or, leaving out the collections of the Peru high school, the remainder averaged about $\frac{3}{4}$ of a specimen to each collection. The insects of these schools number 1,033 specimens, averaging about 20 to each school. Crustaceans number 203 specimens—less than 4 to a school—and the marine invertebrates 65 specimens—a little more than 1 to a school. Cases for the reception of zoölogical specimens are reported in forty instances—an evidence of the willingness of boards of education to provide for natural history material, which is far in advance of the opportunities hitherto enjoyed for obtaining it.

Upon the basis of the data thus obtained, a list of the schools has been arranged in the order of their relative necessities, and the specimens in hand will be issued to the schools as they appear upon this list, as far as the material now available will go.

INVESTIGATION OF THE FOOD OF BIRDS.

No part of the recent work of the Laboratory has excited a wider interest than that relating to the food of birds. These animals, the most abundant of our vertebrates, are so largely and intimately related to agriculture and horticulture, and the question of their value has been discussed so hotly and for so long a time (hitherto with very indefinite and unsatisfactory results) that a thorough investigation, intended to set this question at rest by accumulating facts and figures whose indications should be decisive and unmistakable, has commanded a warm support and awakened a lively expectation. I am glad to say that this expectation is not likely to be disappointed, and that the entire problem is in process of satisfactory solution. Definite and apparently demonstrable conclusions have been reached concerning the food-habits and economical value of several of the most abundant and important birds, and materials gathered for the study of many more species. Partly by using every opportunity to collect the stomachs of birds, and partly by interesting other ornithologists in this work, we have accumulated 3,100 stomachs, representing 184 species, belonging to 38 families. These were preserved in alcohol and labeled with specific name, locality and date. Most of these have been emptied into small vials of alcohol, bearing similar labels and arranged regularly for easy reference. I have thus far made a critical microscopic study of the contents of 475 stomachs, chiefly of bluebirds, meadow-larks and the various species of the thrush family, and have examined, less thoroughly, about as many more. An elaborate paper on the food of the thrush family was prepared for the 18th volume of the "Transactions of the State Horticultural Society," and published in December, 1879. A summary of the preceding paper and a similar full discussion of the food of the bluebird was prepared for the "American Entomologist," and a second paper upon the bluebird's food for the "American Naturalist." About sixty pages of Bulletin

No. 3 of the Laboratory, now in press, will be devoted to a further discussion of this subject. A supplementary report of the food of the thrush family, and other papers, giving a full account of the food of the bluebird and the meadow-lark, have also been prepared for the forthcoming volume of the "State Horticultural Society." Besides the direct study of this subject, much incidental work has been required on related subjects. It was found impossible satisfactorily to determine the fragments of insects found in the food of birds without a cabinet of microscope slides of insect structures, for reference and comparison. Four hundred and eighty-eight of these were therefore prepared, and others are added, from time to time, as occasion requires. Various manuscript keys to the genera of insects, based upon those structures which have been found to last longest in the stomachs of birds, have also been prepared for use in this work. Some of these have apparently a general and permanent value. The discovery that several of our commonest birds feed, to a considerable extent, on beneficial insects, led to a more critical study of the food of our predaceous beetles than had hitherto been attempted; and in the course of this investigation dissections of forty beetles were made, and eighty slides were prepared of the contents of the alimentary canal, for study and permanent preservation. A paper on this subject will also appear in the next Bulletin of the Laboratory. A large number of slides of the seeds of plants have also been mounted for reference in studying the food of the granivorous birds.

INVESTIGATION OF THE FOOD OF FISHES.

The results of the investigation of the food of fishes have likewise proved of special interest and value. The method used was in all respects similar to that of the preceding research. Papers embracing the results of a careful study of the contents of six hundred stomachs are now in press, and will appear in the next Bulletin of the Laboratory. Satisfactory conclusions have been reached respecting the food of most of the species of our spiny-finned fishes, and the food of the young of several genera of other orders. There are probably one thousand stomachs of fishes in alcohol, yet to be examined.

PUBLICATION OF BULLETINS.

The appropriation made for this purpose, at the last session of the legislature, was \$250 per annum. Although the class and origin of the papers whose publication was thus provided for was not indicated by the law, I have inferred that it was intended that this fund should be used, primarily, for the publication of reports upon those subjects which we were required to investigate at the Laboratory, since these investigations would have been of no general value unless the results were published. I have also provided, as far as the funds would allow, for the publication of such original papers upon the natural history of the State as were offered by their authors, preferring among these such as related to subjects bearing more or less directly upon the birds and fishes of the State.

The following papers are now in press for our Bulletins three and four: "On Some Interactions of Organisms," "The Food of Birds," "The Food of Fishes," "On the Food of Young Fishes," "Notes on the Predaceous Beetles," "Notes on the Food of the Carabidæ," and a "Catalogue of the Birds of Illinois." All but the two last of these were prepared at the Laboratory by myself. The paper on the "Food of the Carabidæ" was written by Mr. F. M. Webster, of Waterman, and the list of Illinois birds by Robert Ridgway, formerly of Mt. Carmel, and now of the Smithsonian Institution, at Washington. We have also in hand, for future publication, a descriptive list of the reptiles and batrachians of the State, by Messrs. Rice and Davis, of Evanston; a paper on the leaf-mites, by my assistant, Mr. W. H. Garman; a "Key to the Genera of Illinois Carabidæ," and several shorter papers on miscellaneous subjects.

THE LIBRARY.

No expenditure made by the Laboratory during the last two years has been so immediately profitable, both to the work of the establishment and to the studies of other naturalists, as that made for new books. While the additions are very few compared with the literature needed, they have cleared the field of difficulties which have blocked the progress of our work for years, and have first made possible to the students of our local natural history, original work of a satisfactory character, in a few departments of zoölogy and botany. While the books were purchased for the purpose of facilitating the work of the Laboratory, and are held primarily for our own use, the library is open at all times to the public, and the books are likewise loaned to naturalists at a distance when not needed in the work of the institution. For the benefit of the students of natural science throughout the State, a classified list of the principal works added during the last eighteen months is here inserted:

RECENT ADDITIONS TO THE LIBRARY.

Miscellaneous General Works.

Zoölogical Record, Vols. I-XIV.

Proceedings of the Boston Society of Natural History, Vols. III-XIX.

Journal of the Academy of Natural Sciences of Philadelphia (old series), Vols. I-VIII.

Proceedings of the Academy of Natural Sciences of Philadelphia, Vols. XXVI-XXX, and parts 1 and 2 of Vol. XXXI.

Reports of the New York State Museum of Natural History, 1855-1879.

Proceedings of the United States National Museum, Vols. I and II.

Bulletins of the United States National Museum, Vol. I.

Bulletins of the United States Geological and Geographical Survey of the Territories, Vol. 5, Nos. 1-4.

Smithsonian Miscellaneous Collections, Vols. I-XVII.

Proceedings of the American Association for the Advancement of Science, Vols. I-XXVI.

Transactions of the New York State Agricultural Society, 8 Vols.
 Transactions of the Illinois Horticultural Society, Report for 1879.
 Journal of the Proceedings of the Massachusetts Horticultural Society, 1859.

Transactions of the Hingham Agricultural and Horticultural Society, 1869.

Transactions of the Academy of Sciences of St. Louis, Vol. III, No. 4, and Vol. IV, No. 1.

Proceedings of the Poughkeepsie Society of Natural Sciences, Vol. I, part 1, and from Oct. 1, 1878, to July 1, 1879.

Proceedings of the Davenport Academy of Natural Sciences, Vol. II, part X.

Bulletins of the Minnesota Academy of Natural Science, 1873, '74, '76, '77.

Chesapeake Zoölogical Laboratory, Scientific Results of the Session of 1878.

Transactions of the Kansas Academy of Science, 1874, '75 and '77.

Bulletin of the Bussey Institution, Vol. II, parts I, II and III.

Linné's *Systema Naturæ*, Vols. I-IV.

American Naturalist, Vols. XIII and XIV.

Chicago Field.

Field and Forest.

The Naturalist's Directory for 1880.

Forhandlingerne ved de Skandinaviske Naturforskeres.

Scandinaviens Ætliga och Giftiga Svampar; C. Hartman.

Fünfundzwanzigster Bericht des Naturhistorischen Vereins in Augsburg, 1879.

Bulletin de la Société d'Acclimation, I-VIII.

Archives of Science and Transactions of the Orleans County Society of Natural Sciences, Vol. I, Nos. 1-8.

Preliminary Check-List of the Marine Invertebrata of the Atlantic Coast, from Cape Cod to the Gulf of St. Lawrence; A. E. Verrill.

Notice of Recent Additions to the Marine Invertebrata of the Northeast Coast of America; A. E. Verrill.

Eftversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, 1860 and 1875.

Sitzungsberichte der Physikalisch-Medicinischen Societat zu Erlangen, 1878.

Vierundzwanzigster Bericht des Naturhistorischen Vereins in Augsburg, 1877.

Schriften des Vereins zur Verbreitung Naturwissenschaftlichen Kenntnisse in Wien, 1878 and 1880.

Zeitschrift für Gesamten Naturwissenschaften, Mai-December, 1879.

Om Grundfjeldets og Sparagmitfjeldets Mægtighed i Norge; Professor Theodor Kjerulf.

Stratification; Dr. Theodor Kjerulf.

Om Skuringsmaeker, Glacialformationen, Tereasser og Strandlinier Sanet.

Palaeontological Report of the Princeton Scientific Expedition.

Engineers' Department of the United States Army: Reports upon the species obtained from Borings made in 1874 between the Mississippi River and Lake Borgne, at the site proposed for an outlet for flood waters; Hilgard and Hopkins.

Elements of Comparative Anatomy; Gegenbaur.
 Bronn's Classen und Ordnungen des Thier-Reichs, Vols. I-VI.
 Text-Book of Zoölogy; Packard.
 Handbuch der Zoölogie; Döbner. 2 Vols.
 Skandinavisk Fauna; S. Nillson.
 Elements of Geology; Joseph LeConte.

Works on Mammals.

On the Osteology of *Sciuropterus volucella*, Geoff. G. H. Perkins.

Works on Birds.

North American Birds, Vols. I-III; Baird, Brewer and Ridgway.
 Bulletins of the Nuttall Ornithological Club, Vols. I-IV and Nos. 1,
 2 and 3 of Vol. V.
 Der Vogelschutz; George Ritter v. Frauenfeld.
 Architecture des Nids, Dénichage, Oiseaux Sédentaires; M. F. Lescuyer.
 Classification des Oiseaux de la Vallée de la Marne; M. F. Lescuyer.
 Introduction a l'Etude des Oiseaux; M. F. Lescuyer.
 La Héronnière d'Ecury et le Héron Gris; Lescuyer.
 Langage et Chant des Oiseaux; Lescuyer.
 Giebel's Vogelschutzbuch.
 Die Einheimischen Säugethiere und Vögel; Adolf und Karl Müller.
 Gloger's Vogelschutzschriften.
 The House Sparrow at Home and Abroad; Thos. Gentry.
 Notes on Birds observed in Western Iowa in the months of July,
 Aug. and Sept.; also in N. Ill., in May and June, and at Richmond,
 Wayne Co., Ind., June 3-10, 1867; J. A. Allen.
 A Catalogue of the Birds of Kansas; F. H. Snow.
 From the American Naturalist: Some new Points in the Con-
 struction of the Tongues of Woodpeckers; Dr. J. Lindahl.

Works on Reptiles.

Bulletin of the Museum of Comparative Zoölogy: On certain
 species of Chelonoidæ; Samuel Garman.

Works on Fishes.

Proceedings of the National Museum: Five extracts containing
 descriptions of American Fishes, by Jordan and Gilbert.
 Ichthyology of South Carolina; Holbrook.
 Southern Ichthyology; Holbrook.
 Descriptions of two new species of Fishes (*Macrurus bairdii* and
Lycodes verrillii); G. B. Goode and T. H. Bean.
 From American Journal of Science and Arts: Discoveries of the
 United States Fish Commission; notices of fifty species of East
 Coast Fishes, many of which are new to the fauna; G. B. Goode
 and T. H. Bean.
 Bulletin of the Museum of Comparative Zoölogy: New species of
 Selachians in the Museum collection; Samuel Garman.

Partial Synopsis of the Freshwater Fishes of North Carolina; E. D. Cope.

A Contribution to the Ichthyology of Alaska; E. D. Cope.

Synopsis of the Coldblooded Vertebrates procured by Prof. James Orton during his Exploration of Peru in 1870-77; E. D. Cope.

Miscellaneous General Works on Insects.

An Introduction to Entomology, or Elements of the Natural History of Insects, 3 vols.; Kirby and Spence.

Entomological Correspondence; Harris.

Practical Entomologist; Vols. I and II.

Transactions of the American Entomological Society, Vols. IV-VII.

American Entomologist, Vol. I (except Nos. 2, 3 and 5), Vol. II (except Nos. 4 and 11), and Vol. III (except No. 12).

Economic Entomology, Aptera; Andrew Murray.

Entomological Notes, I-VI; S. H. Scudder.

Reports on the Noxious, Beneficial and other Insects of the State of Missouri, 1-9; Riley.

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Formic. Nov. Amer.; " "

Neue Formic.; " "

Bidrag til dansk Myers; Meinert.

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Om några Arachnider från Grönland; T. Thorell.
Om Arachnider från Spetsbergen och Beeren-Eiland; T. Thorell.
A New Fossil Spider from the Coal Measures of Illinois; O. Harger.
Spiders: Their Habits and Structure; J. H. Emerton.
Ueber Milben; F. A. Zürn.
Mémoire Zoologique et Anatomique sur diverses especes d'Acariens de la Famille des Sarcophtides; Robin.
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Eine Milbe (*Phytoptus vitis mihl*) als Ursache des Trauben-Messwachses; Dr. H. Landois.

Beiträge zur Naturgeschichte der Gallmilben (*Phytoptus*, Duj.); Dr. Franz Löw.

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Sulla *Phytoptosi della Vite* (*Phytoptus vitis*, Landois); Giovanni Briosi.

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Histoire Naturelle des Acariens; H. M. Nicolet.

Intorno Agli Acari Italiani; Prof. F. Fanzago.

Aeltere und neue Beobachtungen ueber *Phytoptoecidien*; Dr. Freidrich A. W. Thomas.

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Ueber *Phytoptus*, Duj.; F. A. W. Thomas.

Works on Myriapoda.

Bidrag till Skandinavien Myriopodolgi; Anton Stuxberg.

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Thranites; C. Bovallius.

Notes on *Pterygocera arenaria*, Slabber; C. Bovallius.

Notes on some new or little known species of Fresh-water Entomostraca; John Lubbock.

On the Structure and Functions of the Hairs of Crustacea; C. DeMorgan.

On the Embryology of *Limulus polyphemus*; Packard.

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Das Genus *Cyclops* und seine einheimischen Arten; Claus.

Neue Beobachtungen über Cypridinen; Claus.

Beobachtungen über *Lernæocera*, *Peniculus* und *Lernæa*; Claus.

Beiträge zur Kenntniss der Ostracoden; Claus.

Parasitic Crustacea; Claus.

Neue Beiträge zur Kenntniss Parasitischer Copepoden nebst Bemerkungen über das System Derselben; Claus.

Notice of some Genera of Cyclopæcea; J. D. Dana.

Conspectus Crustaceorum in Orbis Terrarum Circumnavigatione, Caroli Wilkes; Dana.

A Review of the Classification of Crustacea with reference to certain Principles of Classification; Dana.

Synopsis of the Genera of Gammaracea; Dana.

On the Origin of the Geographical Distribution of Crustacea; Dana.

Om tvenne Europeiska Argulider: jemte anmärkningar om Argulidernas Morfologi och Systematiska Ställning, samt en Öfversigt af de för närvarande Kända Arterna af denna Familj; F. Thorell.

Om *Argulus dactylopteri*, en ny Vestindisk Hafsargulid; Thorell.

List of the Decapod Crustacea of the Atlantic Coast, whose range embraces Fort Macon; J. S. Kingsley.

Notes on the Geographical Distribution of the Crustacea; Kingsley.

On a Collection of Crustacea from Virginia, North Carolina and Florida, with a revision of the Genera of *Crangonidæ* and *Palæmonidæ*; Kingsley.

Notes on North American Decapoda; Kingsley.

The Development of *Moina*; Kingsley.

Barnacles; Kingsley.

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Note sur le *Nephrops stewartii*, W. Mason; Milne-Edwards.

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Ueber eine Süßwassererustace im Nil, von Dr. C. B. Klunzinger, mit Zusätzen von Dr. Ed. v. Martens und C. Th. v. Siebold.

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Sudbrasilische Süß- und Brackwasser-Crustaceen nach den Sammlungen des Dr. Reinh. Hensel; Ed. v. Martens.

Report of Prof. S. F. Baird, U. S. Commissioner of Fish and Fisheries: Crustacea of the Fresh Waters of the United States; Sketch of the Invertebrate Fauna of Lake Superior; and Food of Fresh Water Fishes; S. I. Smith.

Recherches sur les Crustaces d'Eau Douce de Belgique; Felix Plateau.

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Histoire Naturelle des Crustacés; A. Risso.

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Notes on Cladocera; E. A. Birge.

The Crayfish; Huxley.

A Revision of North American Astaci, with Observations on their Habits and Geographical Distribution; Chas. Girard.

Note sur la Variété rouge de l'Ecrevisse Commune, *Astacus fluviatilis* (Rondelet); M. Godefroy Lunel.

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Description of two new Species of Terrestrial Grapsoid Crustaceans from the West Indies; Theodore Gill.

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A Synopsis of the Pycnogonida of N. Eng.; Edm. B. Wilson.

On the British Species of *Alpheus*, *Typton* and *Axiu*, and on *Alpheus edwardsii*; A. M. Norman.

Sui Crosteacei di Formi Marine viventi nelle Acque dolci e specialmente sul *Palæmon palustris* di Martens; Torquato Taramelli.

Tvenne nya Oniscider, beskrifne; Anton Stuxberg.

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- Dänmarks Isopode Landkrebsdyr; G. Budde-Lund.
 Lernæocera Gasterostei; Carl Bernhard Brühl.
 Carcinologiske Bidrag til Norges Fauna; Sars.
 Bidrag til Kunskab om det aabne Havs Snyltekrebs og Lernæer, samt om Nogle Andre nye eller hydtill kun ufuldstændigt Kjendte parasitiske Copepoder; Steenstrup og Lütken.
 An Examination of Types of some Recently Described Crustacea; Streets and Kingsley.
 Ueber Bau und Lebenserscheinungen von Leptodora hyalina; Dr. August Weissmann.
 Observations Anatomiques et Physiologiques sur le Genre Cyclops; H. Vernet.
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 Carcinologiske Bidrag til Norges Fauna; Sars.
 Characters of New Species of Crustacea Discovered by G. K. Lord on the Coast of Vancouver's Island; Spence-Bate.
 Beiträge zur Kenntniss der Entomostraceen; Fischer.
 Prodromus Faunæ Copepodorum parasitantium Scandinaviæ; Dr. Petrus Olsson.
 Occurrence of Chelura terebrans, a Crustacean Destructive to the Timber of Submarine Structures on the Coast of the United States; S. I. Smith.
 Beschreibung einiger neuen oder weniger bekannten Schmarotzerkrebse, nebst Allgemeinen Betrachtungen über die Gruppe, welcher sie angehören; Burmeister.
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 Observations on the Genus Unio. Vols. I-XIII; Lea.
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Works on Worms.

On the Classification of some of the Lower Worms; C. L. Minot.
Parasites, a Treatise on the Parasites of Man and Animals; Cobbold.

Entozoa, 2 vols.; Cobbold.

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Descriptions of some imperfectly known and new Ascidians from New England; Verrill.

Rotatoria Hungariæ; Dr. Bartsch Samu.

General Works (chiefly on Vermes, Cœlenterata and Echinodermata.)

On some remarkable Forms of Animal Life from the great Deep off the Norwegian Coast, Parts I and II; Sars.

Notes on the Radiata in the Museum of the Yale College, 1-9; Verrill.

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Revision of the Polyps of the Eastern Coast of the United States (Mem. Bost. Soc.); A. E. Verrill.

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Memoirs of the Boston Society of Natural History: Revision of the North American Poriferæ, Parts I and II; Alpheus Hyatt.

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Works on Histology, Pathology and Microscopy.

Micrographic Dictionary; Griffith and Henfrey.
 Cursus der Normalen Histologie; Orth.
 Billroth's Surgical Pathology; Hackley.
 A Manual of Histology; Stricker.
 Pathology and Morbid Anatomy; Greene.
 Practical Examination of Urine; Tyson.
 Student's Primer of the Urine; Whittaker.
 Hand-book for the Physiological Laboratory; Sanderson.
 Frey on the Microscope and Microscopic Technology; Cutter.
 Manuel d'Histologie Pathologique, I, II et III; Cornil et Ranvier.
 Cellular Pathology; Virchow.
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 Pathologischen Anatomie; Dr. Edward Rindfleisch.

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Systema Vegetabilium; Linné.
 Die Pflanzenwelt Norwegens, ein Beitrag zur Natur-und Cultur-
 geschichte Nord-Europas; Schübeler.
 Plants and their Growth; Prof. T. J. Burrill.
 First Annual Report upon Useful and Noxious Plants; Burrill.
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 in North America, from 1635 to 1858; Dr. F. Brendel.
 Willows of California; M. S. Bebb.
 Hepaticæ Boreali Americanæ; C. F. Austin.
 Musci Appalachani; Austin.
 Icones Fungorum, 6 vols; Corda.
 Hymenomyces Europæi; E. Fries.
 Mycologia Europæa; C. H. Persoon.
 Les Champignons de la France; F. S. Cordici.
 Icones Selecti Hymenomycetum; E. Fries.
 Micrographia; M. C. Cook.
 Myzomycetes of Great Britain; Cook.
 Iconographie des Champignon; Paulet et Seville.

FINANCIAL.

The terms in which the appropriations for the Laboratory were made required a distribution of the expenditures under a number of different accounts. As in many cases the expenditures were made for several purposes in common, this distribution is frequently artificial and arbitrary. While the appropriation is divided into specific sums, for various purposes, most of the expenditure must be made for several purposes conjointly. The cost of apparatus and material, the expense of the field work and miscellaneous assistance, the office expenses, etc., are not properly chargeable to any one of the funds alone, since the benefits resulting accrue in part to the State Museum, in part to the educational institutions, in part to the public schools, and so through the list. Neither is it possible to tell, if an attempt is made to divide each item of the

expenditures among the various accounts, how much of a barrel of alcohol, for example, or the cost of a seine, or of a pound of powder should be charged under each head. The only practicable way has been to charge to each account such expenditures as properly belong there and nowhere else, and to divide the expenditures made for two or more purposes among the corresponding accounts, according to the conditions of the funds and the necessities of the work. For this reason I would suggest that in future the field and general expenses of the Laboratory be provided for by the appropriation of a lump sum, and that the expenses of the preparation of material for the different institutions dependent upon us, and for the different classes of work required of us, be provided for separately, by different items of the appropriation. I give, herewith, an exhibit of the expenditures for the year closing June 30, 1880, classified according to the items of the appropriation, and showing the purposes for which the expenditures were made under each account. [For Financial Report, see page 127.]

WORK FOR THE FUTURE.

In addition to the various enterprises now in hand, which it is proposed to carry steadily forward to completion, two subjects press upon us for immediate consideration—those of parasitic fungi, and the parasites of the domestic animals. Certainly the agricultural and horticultural interests of the State are subject to no more serious drain than that caused by diseases due to parasitic fungi. Hundreds of thousands of dollars each year are lost through our ignorance of the causes of these diseases and the laws of life of the plants which produce them, and especially through our total ignorance of any practical means of controlling them. That the problem thus presented is not insoluble is shown by the recent and most important discovery, by Prof. Burrill, that the pear-blights and the yellows of the peach, and other similar destructive diseases, are due to the action of bacteria; and since those diseases of man and other animals, which are undoubtedly caused by similar organisms, have been found more or less subject to human control, there is every reason for encouragement in the practical investigation of the corresponding diseases of plants. Believing this to be the most important biological subject now before us, so far as relates to the economical interests of the people. I have taken measures for active work in this department. The most essential part of the literature of the subject has already been ordered from Europe, and the collection of our fungi has been actively prosecuted during the last three years. We have thus accumulated what is probably by far the largest collection of this class of plants in the western States. We have now four hundred species of Illinois fungi in the collection, which have been determined by Prof. Peck, of the New York State Museum, at Albany, and about one hundred and fifty species whose names have not yet been received. From North America, outside the State, we have about one thousand named species of these plants, and in addition to these something over fifteen hundred species of foreign fungi. The condition of the collection is not, at present, such as to enable us to give exact

FINANCIAL REPORT

For the year ending June 30, 1880, of the State Laboratory of Natural History, at Normal, and of the State Historical and Natural History Museum, at Springfield.

RECEIPTS FROM APPROPRIATIONS.

For supply of State Museum.....	\$1,000 00	
For supply of State educational institutions.....	250 00	
For supply of public high schools.....	250 00	
For investigation of food of birds.....	200 00	
For investigation of food of fishes.....	150 00	
For publication of Bulletins.....	250 00	
For Library:		
New books.....	1,000 00	
Cataloguing.....	100 00	
For pay of assistant.....	800 00	
		\$4,000 00

EXPENDITURES.

State Museum:		
For field expenses of collecting parties.....	\$128 61	
For collecting apparatus and materials.....	63 64	
For transportation.....	109 76	
For skins of mammals.....	105 50	
For taxidermist's materials.....	13 12	
For cost of preparing skeletons.....	42 90	
Pay of taxidermist and osteologist.....	185 00	
For work on herbarium and materials.....	92 75	
For materials for fish casts and tablets.....	58 62	
For work on fish casts.....	158 75	
For purchase of specimens.....	85 00	
For packing-boxes and other sundries.....	19 95	
		\$1,063 60
State Educational Institutions:		
For expenses of collection of birds, plants, insects and fishes.....	\$181 35	
For collecting apparatus and materials.....	12 60	
For transportation.....	5 50	
For purchase of specimens.....	2 35	
For work and materials for entomological collections.....	50 13	
For work on herbarium specimens.....	11 55	
For sundries.....	1 25	
		264 73
Public High Schools:		
For collection of specimens.....	\$191 25	
For preservation and preparation of specimens.....	50 57	
For labor on collections.....	27 15	
		268 97
Investigation of Food of Birds:		
For field expenses.....	\$19 30	
For materials for collection and preservation of specimens.....	23 43	
For transportation.....	17 38	
For preparation of microscope slides.....	114 50	
For collection of seeds.....	2 85	
For blanks and record books.....	28 50	
For sundries.....	1 25	
		207 21
Investigation of Food of Fishes:		
For field expenses.....	\$89 05	
For collecting materials and apparatus.....	21 30	
For materials for microscope.....	49 25	
		159 60
Publication of Bulletins:		
For printing.....		65 66
Library:		
For purchase of books.....	\$587 83	
For transportation.....	27 15	
For binding.....	88 50	
For cataloguing.....	60 00	
		763 48
For pay of assistant.....		820 00
Balance.....		386 75
Total expenditures.....		\$4,000 00

numbers; but, allowing liberally for duplicates received from these various sources, we may say that we have now from two thousand to twenty-five hundred species of fungi in the collection, represented by excellent specimens and named by the best authorities in this country and in Europe. The special needs for the future success of this work are, larger collections of the Illinois species, the complete organization of these collections, and an increase of the library, which is especially deficient in the more costly illustrated works, upon which the investigator must depend largely if he would undertake original work. In the determination and the description of species we have been assured of the invaluable aid of Prof. T. J. Burrill, of the State Industrial University. For the study of parasitic animals considerable additions to the library, and a collection of authoritatively named specimens, will be essential, with some assistance in the preparation of material. I have made no especial estimate for the expenses of this undertaking, but can provide for them from the general funds asked for.

In the future field work of the laboratory it is proposed to take the State in detail, dividing it into four or five regions, and reporting upon the entire natural history of each region, separately. This will give opportunity for a more thorough, general view of the actions and reactions of the plants and animals of each region, such as is necessary to the practical application of the results arrived at. We shall also, by this method, be able to utilize the observation and assistance of local naturalists throughout the State, stimulating the local interest and activity in whatever relates to the natural history of each region. This can all be done without interfering in any way with the more general objects to which the institution is devoted.

For the State Museum, collections in all departments should be carried on to completion, as all are incomplete. The ornithological collection is the largest of any, but this lacks about thirty species which have been ascertained to occur in the State since the contract with Mr. Worthen was made. It is very desirable that this collection should be finished, since it lacks so little of completion, and the additional material can be obtained at such slight expense. The work for the State institutions it is proposed to continue in the same direction and on about the same scale as heretofore. The high schools of the State, which are in evident and immediate need of Natural History material for the illustration of the studies of their course, are not over one-third supplied with zoological specimens. The cost of this material, when furnished by the laboratory, is so trifling, and its utility to the schools is so great, that probably no objection to the continuation of this work will be encountered from any source. For the investigation of the food of birds, nearly as much additional material is needed as is now in hand. Collections from Southern Illinois are especially to be desired, as those made hitherto are confined almost entirely to the northern two-thirds of the State. For the completion of the work on the food of fishes, more material is needed, and also some assistance. Much of the mechanical work of this investigation and the preceding can be done by an ordinary assistant, in a way to facilitate, greatly, the progress of these researches. For the publi-

cation of bulletins the present fund has been found quite insufficient. Much valuable matter, prepared by our local naturalists, it has not been possible to publish. I have, therefore, asked for a larger sum than usual for publications. Notwithstanding the enlarged operations proposed, I find that these can be carried forward for about the same sum as previously appropriated, if it is thought best to cut down the library appropriation to about one-half the present amount. Rather than ask for increased appropriations, I have proposed to reduce the item for the library so as to bring the total amount asked for at this session within the sum of the appropriation made at the previous session of the legislature.

Respectfully submitted,

S. A. FORBES,

Director of Laboratory.

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REPORT

— OF THE —

DIRECTOR OF THE STATE LABORATORY

— OF —

NATURAL HISTORY,

FOR THE TWO YEARS, ENDING JUNE 30, 1881, AND JUNE 30, 1882.

R E P O R T

— OF THE —

DIRECTOR OF THE STATE LABORATORY

— OF —

NATURAL HISTORY.

HON. JAMES P. SLADE, *Superintendent of Public Instruction:*

DEAR SIR—The work of the State Laboratory of Natural History, as defined by the various statutes referring to it, and indicated by the appropriation bill of the last session, is essentially that of a zoölogical and botanical survey of the State, conducted with principal reference to economic questions, and to the interests of public education. It has been continued during the past two years on about the same lines as those described in my last report, with the exception of a very great enlargement in Entomology and Botany. The subjects now included in its scheme of operations are, the supply of natural history material to the State Museum, to the State educational institutions and to the public high schools; the investigation of the food of birds for the benefit of agriculture and horticulture, and of the food of fishes in the interest of fish culture; a study of the parasitic plants and animals of the State (a subject of importance to the stock and general farmer); and the publication of bulletins of original research relating to the natural history of Illinois. The appropriations made to the laboratory are for the field and laboratory expenses of these subjects, and for the improvement of its library.

FIELD ZOÖLOGY.

On account of the exhaustion of the appropriations for that purpose, but little field work in either zoölogy or botany could be done in the spring of 1881, and but three trips were made previous to July 1, when the new appropriation became available. In April, Mr. W. H. Garman and myself spent a week at Pekin and Peoria, making collections of fishes for distribution, and of stomachs of fishes, for the study of their food. In May, a few days were spent in shooting birds and collecting predaceous insects in orchards, in Tazewell county, infested by the canker worm. In June, I made an extensive trip through Southern Illinois, from Centralia to Cairo, and thence up the Ohio to Shawneetown, and back by way of Mount Vernon, collecting birds and insects by the way, and examining the country with reference to the further field work of the season. It was decided, partly as the result of this trip, to concentrate during the fall of 1881 chiefly upon the aquatic fauna of Northern Illinois. After a brief trip to Pekin in the middle of June, for the further collections of fishes and their food, preparations were made for an elaborate work upon the lakes in the northeastern part of the State,

and also upon Lake Michigan. In the course of these preparations I made a trip to the sea coast, for the purpose of examining the apparatus and witnessing the work of the steamer Fish-hawk, engaged upon the Atlantic ocean in explorations similar to those which it was my purpose to undertake in Illinois. After examining the laboratory and appliances of the fish commission in their establishment at Wood's Hole, Mass., I went out with the party upon the Fish-hawk to their collecting grounds on the borders of the Gulf Stream, and studied their methods of deep-sea work. On my return, I purchased in Boston the necessary outfit of dredges, trawl, towing-nets, sounding lines, etc., and took the field for active work upon Lake Michigan about the twentieth of September. For in-shore operations near Chicago, a Mackinaw boat was hired, with a sailor in charge, and about two weeks were spent in continued dredging along the shore from Hyde Park to Evanston, from the harbor to about ten miles out. In order to obtain material for the study of the bottom fauna of the deeper regions of the lake, a trip was made to Grand Traverse Bay early in October. Here, with the assistance of a steam tug and a crew of four men, the dredge and trawl were hauled repeatedly in water ranging from a depth of thirty to one hundred and two fathoms, and the margins of the bay were searched thoroughly and carefully from a yawl.

In the meantime an assistant, Mr. Cyrus W. Butler, had been established at South Chicago with instructions to make collections of all kinds from the lake and from the adjacent waters, and also from the country round about, with especial reference to the needs of the State Museum, the State educational institutions, and the public high schools. To the generosity of Haussler Brothers, a firm of fishermen, he was indebted for an excellent and convenient work room, furnished him free of charge. He made here a large collection of birds, fishes, and small aquatic animals, and prepared molds for about thirty casts, remaining from the first of August until about the middle of October.

In addition to these operations upon Lake Michigan, work was diligently prosecuted upon the small lakes of Lake and McHenry counties. Fox, Nippersink, Long, Defiance and Griswold Lakes were sounded and thoroughly dredged, and full collections made of the plant and animal life of each, from the shore to the deepest water. For a comparison of these shallow lakes with deeper ones farther north, a trip was made October 11 to Geneva Lake, Wis. The steam launch of the Hon. N. K. Fairbanks, of Chicago, generously placed at our disposal, gave us an unusual opportunity for the study of this lake. Soundings were made in all parts of it, and the dredge and trawl were hauled in various depths, from one to twenty fathoms, for distances aggregating more than two miles. No attempt was made at this time to determine the fish fauna of any of these waters, this being necessarily postponed until the following season. This closed the field work for the season of 1881.

The first trip of the following spring was made in February to Racine, Wis., for the purpose of collecting the Entomostraca and smaller organisms generally from the water of the lake at the time and place of deposit of several million young whitefish, planted by the U. S. Fish Commission. These collections were obtained to test

the presence and abundance of those organisms upon which the young whitefish depend for their earliest food, and to obtain material for a further study of this subject. An assistant was also sent to Iroquois county in this month, to examine the eastern part of the State with reference to future aquatic work in that region. In April, Mr. F. M. Webster, an entomological assistant in the Laboratory, collected insects in the counties of Union and Jackson, in Southern Illinois, returning early in May. During the latter month, Mr. N. K. McCormick and myself went to the eastern part of Lake county for a continuance of the work of the preceding season upon the lakes. We used the dredge, towing net and sounding line in Sand, Miltimore, Deep and Cedar Lakes, and also made some small collections of fishes, returning about the middle of the month.

Later, additional collections of birds and predaceous insects were made in Tazewell county, to obtain material for a further study of the relations of these groups to canker worms. In June, advantage was taken of the meeting of the State Natural History Society to use the dredge in the Mississippi river, at Alton, and to collect insects between that place and Grafton.

Early in July, having been appointed State Entomologist, I started upon an extended trip through Northern Illinois, to investigate the injuries done by insects to the growing crops, with a view to selecting subjects for a more detailed study by myself and assistants, later in the season. On this trip I went from Champaign to Chicago and Waukegan, thence to Freeport, and southwards to La Salle; making observations and collections at these and many intermediate points. August 15, Mr. McCormick was established on the Illinois river, to obtain additional material for the study of the food for fishes, and for the purpose of procuring specimens for distribution to the public schools. He stayed here during the remainder of the month, and returned, also, late in September, for a week's additional work. On the sixteenth of August I made a visit to Stark and Putnam counties, and carefully studied the corn-root worm and its injuries to corn in that vicinity. The latter half of August was spent by Mr. Webster in La Salle and DeKalb counties, where he was sent on a similar errand, and instructed to make general collections in entomology. Early in September, Mr. McCormick and myself visited the lower Illinois river, making exhaustive collections of fishes and other aquatic animals from the river itself and its tributaries and from the lakes in the river bottoms. Late in this month Mr. McCormick was sent to Fox river, in Kendall county, for additional material from that stream and its branches. Mr. W. H. Garman spent the greater part of September in Southern Illinois, from Centralia to Villa Ridge, carefully studying insect injuries to the strawberry. He also made large collections of fishes and insects from the region visited. The latter days of September and the first week in October were spent by him in the Wabash valley, near Carmi, chiefly in ichthyological work. Upon his return I went with him to Cedar Lake, in Northern Illinois, for the study of the plant and animal life of that lake, selected as a type of the lakes of Northern Illinois. Soundings were made in every direction, in this and in Deep Lake, adjoining. Temperatures of the water, at the surface and bottom, were taken, by means of a deep-sea thermometer, and everything

obtainable at that season of the year was collected, from every part of the lake, studied while fresh, and preserved for further examination, as far as it was capable of preservation. The objects secured were intended to give a complete knowledge, not only of the species occurring in this lake, but of their exact distribution, and the situations in which they were found most abundant. Sufficient numbers of each species were preserved to give the best possible idea of its food, and of the general system of relations by which the organisms of such a body of water are held together. Similar work was also done in adjacent lakes. The first half of November was spent by me in Southern Illinois, whither I went for a further study of the insects injurious to the strawberry. I also improved the opportunity to make collections for a study of the autumnal food of the common birds of Southern Illinois, and returned by way of Champaign, for an examination of the winter state of the chinch bug, in the fields near that place. In addition to the trips above enumerated, the entire country about Normal, over a radius of from ten to fifteen miles, has been regularly searched, at every favorable opportunity. In this vicinity, especially, careful studies were made of the life histories of the chinch bug, the corn-root worm, the cucumber aphid, and such other injurious insects as became either numerous or destructive enough to attract attention. During the two seasons covered by this report, the time spent in the field for zoölogical work by myself and my assistants amounted to fifty-one weeks.

FIELD BOTANY.

The sum of \$500 per annum was appropriated at the last session of the Legislature for field work in botany, and Mr. A. B. Seymour, a thorough student of the lower fungi, was engaged for this purpose. In order to enable him to spend all his time in the actual accumulation of specimens, Miss Rachel M. Fell was detailed to receive his material, as it arrived at the laboratory daily by express, to put it through the press and prepare it for the herbarium.

July and the first half of August, 1881, were spent by him in McLean, Champaign and Piatt counties. He then visited Lake, Kane and McHenry counties, returning by way of South Chicago and LaSalle. The latter part of September and the first days of October he spent in Rock Island, Fulton and Peoria counties. On the 20th of October, he went to Southern Illinois, and made collections in Marion, Union and Jackson counties, returning November 5. The last days of the collecting season he spent at Champaign. In April of the following year, he took the field again in Southern Illinois, made large collections throughout Union, Pulaski, Alexander and Jackson counties, and returned in the latter part of May. Champaign and LaSalle counties were visited during the first half of June, and from June 25 to the 15th of July he collected in Adams county. The month of September was spent in Northern Illinois, chiefly along the line of the Illinois Central railroad, from Galena to LaSalle. His last trip was made to Jersey county and the bottoms of the lower part of the Illinois river, during October. Collections in all these regions were confined principally to the parasitic fungi, although he used all opportunities to secure for the Laboratory and independ-

ent institutions, examples of all rare or especially desirable plants in other orders. His activity and success as a collector are evidenced by the fact that he has used, during this year and a half of field work, more than 3,500 catalogue numbers, and has sent to the Laboratory not far from 200,000 specimens. In addition to the preparation of these for the Herbarium, Miss Fell has mounted over 1,000 slides of fungi for the microscope.

STATE MUSEUM.

The collections sent to this institution during previous years naturally represented the most abundant species, as a general rule, and were consequently larger than those made this year, for which we have had to draw on much rarer material. Nevertheless, large additions will be made to the number of fishes, insects and plants in the Museum (especially of the last), as fast as they are determined. The work on these collections has not yet progressed far enough, however, to enable us even to estimate the amount available for the Museum. A mounted elk (female) has been placed in the exhibition room since my last report, and several casts of fishes, mounted birds, and skeletons of mammals and birds, are now ready for shipment. A collection of sixty species of eggs and twenty-five of nests is also ready. Twenty-one skeletons, engaged of Mr. C. W. Butler, and intended for the Museum, were unfortunately burned while still in his possession.

STATE EDUCATIONAL INSTITUTIONS.

It is also impossible to estimate with any exactness the material now in hand for the State Industrial University at Champaign, or the Southern Illinois Normal at Carbondale. The collections promised by my last report were forwarded about as there represented, and similar ones will be ready by January 1. Besides these, skins of fifty-nine species of birds were sent to the Southern Illinois Normal in 1881, and twenty-nine species were sent at the same time to the Industrial at Champaign.

SUPPLY OF PUBLIC HIGH SCHOOLS.

Eight thousand specimens were distributed to thirty public high schools, about six thousand of them insects, the remainder nearly all fishes and marine invertebrates. The schools supplied were selected according to their necessities, by the plan explained in my previous report. At least as large a number of other schools will be furnished with similar sets of specimens this fall. Circulars of inquiry respecting the needs of the schools have recently been sent out to those not reached last year, and twenty-seven replies requesting sets of specimens, and promising proper facilities for their arrangement and preservation, have already been received.

INVESTIGATION OF THE FOOD OF BIRDS.

The collection designed to illustrate the food of birds has been more than doubled in the last two years, and now numbers over six

thousand stomachs, representing about two hundred species. Eight hundred and eighty of these have now been exhaustively studied, and several papers giving the results of some of my recent investigations have been published in the transactions of the State Horticultural Society. Seventy pages of Bulletin 3 of the Laboratory were given to a full report on the food of the thrushes and the blue-bird, and a paper is now in progress for Bulletin 6, giving the results of an elaborate study of the relations of birds to the canker-worm, and to the oscillations of injurious insects in general. Similar studies are in progress on the food of the arboreal birds, and a report on this subject will be ready for the press before spring.

INVESTIGATION OF THE FOOD OF FISHES.

The collections illustrating the food of fishes represent about fifteen hundred specimens, including nearly all the species found in the State. Half of these have now been exhaustively studied, and most of the results have been published in the Laboratory bulletins. In Bulletin 3 was an elaborate description of the food of the spiny-finned fishes of the State, and of the young of all orders. Especial attention has been given, during the last two years, to the food of the young whitefish—a subject of peculiar importance and difficulty. A careful study was made of the contents of the intestines of several hundred of the young fry sent me from the whitefish hatchery of the U. S. Fish Commission at Northville, Michigan, and the conclusions thus reached were tested by experiments on the young, kept first at the Laboratory, and afterwards, to the number of several thousand, in a tank at the Exposition building in Chicago. These specimens were fed with an abundance of all the minute plant and animal life obtainable from the lake, and the kinds selected were determined by the dissection of large numbers of specimens made at regular intervals. The minute life of the lake has been thoroughly studied in this connection to determine the variety and abundance of food available for the young fishes at various places and at all seasons of the year.

PARASITIC PLANTS AND ANIMALS.

Work on this subject (added to the duties of the Laboratory by the Legislature at its last session), has already been partly described, as far as it relates to plants, under the head of field botany. The various collections of parasitic plants made by the botanical assistant, are in process of determination and description by him and by Prof. Burrill at Champaign, and the first of a series of papers on them will be published this year in the Bulletins of the Laboratory. Besides the collections made in the State, nearly four thousand species of named fungi (chiefly parasitic) have been bought, including all the exsiccati of Thuemen, Ellis, and Cook and Ravenel.

The necessary books have been obtained for a study of the parasitic animals of the State, and measures have been taken for regular supplies of material, chiefly from slaughter-houses in different parts of the State. These have not yet been received, however, in quantities sufficient to justify publication of the results.

PUBLICATION OF BULLETINS.

Since my last report, two Bulletins (3 and 4) have been issued from the Laboratory. and Nos. 5 and 6 are now in press. No. 3, of 160 pages, was devoted entirely to the food relations of birds, fishes and insects, and to certain general subjects growing out of these; and No. 4 contains a complete list of the birds of Illinois, with notes of migrations, distribution and abundance. The numbers now in process of publication will contain additional papers on the food of birds, fishes and insects; papers on the fungi of the State, and the first of a series on our aquatic fauna, giving an elaborate account of the species occurring in our lakes, and of the conditions of life prevailing there.

IMPROVEMENT OF THE LIBRARY.

In purchasing books, the policy constantly kept in view has been that of providing a working library for actual use. Only such books and papers have been obtained as were positively necessary to the work of the Laboratory, and these have been supplied usually upon one subject at a time, as the demands of the original research in progress required. For similar reasons particular attention has been paid to cataloguing, and this has been kept fully abreast of the additions. A card catalogue of authors is now absolutely complete to date, and a subject catalogue is well under way. The additions to the library made since my last report number 360 volumes and 200 pamphlets. Many of these are rare and costly works—the foundation stones of zoölogical and botanical literature. The most important accessions have been made in the botanical department, and these alone number over 100 volumes. The accommodations of the library has compelled us to empty all the wall cases of specimens, with which they have hitherto been filled, and to place the books in these. The specimens removed we could only store until such time as suitable provision may be made for them.

FINANCIAL.

The financial statement of my last report, terminated with June 30, 1880, and that hereto appended covers the two succeeding years, namely, the last year of the appropriation made to the Laboratory by the Legislature of 1878, and 1879, and the first year of the appropriation made by that of 1881 and 1882. As the terms of the first appropriation differ somewhat from those of the second, the financial statements for the two years are made separately.

ASSISTANCE.

So much of the gratifying progress and conspicuous success of the work of the Laboratory, is due to the active and devoted labors of my assistants, that it would be inexcusable to omit a more definite mention of their names. Upon Mr. F. M. Webster has fallen the principal part of the entomological work, both in the field and in the Laboratory, since February, 1882, although Mr. W. H. Garman has divided these labors with him since his re-engagement in August

of this year. The latter gentleman is also responsible for most of the drawings made to illustrate the published papers. The work of Mr. A. B. Seymour as botanical assistant has already been described, as has also that of Miss Rachel Fell, in the same capacity. Miss Fell has also finished off nearly all the microscope slides, of whatever character, including the many hundreds made in the study of the food of insects and of young fishes. Mr. Cyrus Butler has been the taxidermist of the institution, although not engaged continuously.

Mr. A. K. McCormick has been the general assistant since July, 1881, and has also done most of the field and Laboratory work on fishes and the other aquatic collections. The librarian of the institution is Miss A. V. Milner, and to her industry and accuracy we owe the admirable card catalogue just finished. Mr. C. A. Hart, my efficient secretary, is responsible for the correspondence, for the preparation of papers for the press, the correction of proofs, and other clerical service. To this little corps of indefatigable workers my most grateful acknowledgments are due, not only for the difficult tasks accomplished, but for the admirable spirit of devotion to the best interests of the Institution in which their studies and their labors have been carried forward.

CONCLUSION.

The practical completion of some parts of the work of the Laboratory, and the enlargement and growing importance of others, will make necessary a reconsideration of the plan of its operations, and a partial re-organization of some of them. The most important part of the field work is finished, both in zoölogy and botany, with the exception of the subject of entomology. It is not to be expected that the Laboratory collections are absolutely complete in any department, much less that complete sets have been sent to any of the institutions supplied by us, but it remains true that those still wanting can be secured with less expenditure for field work than has hitherto been necessary. When some parts of southern and southeastern Illinois, some of the western part of the State, and parts of the Rock River Valley have been more thoroughly examined, little general field work in zoölogy will remain to be done.

The botanical field has not been so thoroughly explored, but the classification of the material already gathered will be a work of some years, and remaining collections necessary can be made to better advantage after those now in hand have been worked up. In fact the time has fully arrived for an orderly summing up and generalization of results and for the publication of systematic reports, in order that the essential end of all, the advancement of science and the education of the people, may be more directly and rapidly promoted.

It is proposed, therefore, to turn the operations of the Laboratory, during the coming two years, chiefly in this direction, to complete, if possible, the study of the food of all the most important birds, to prepare a report on the destructive parasites of the domestic animals, based principally on the collection now making for the Laboratory, to complete the determination of the great quantities of specimens now in our possession, to set on foot a system of exchanges throughout

this country and Europe, which will serve greatly to enlarge the collections of the Laboratory, the State Museum, and the State educational institutions, and to commence the publication of a series of illustrated reports based on this material, which, when finished, shall enable every intelligent citizen and every high school pupil in the State, to acquire a good working knowledge of the plants and animals of his locality. It is not proposed to enter upon the preparation of elaborate descriptive papers on groups of animals or plants, (such as birds and phænogams) on which sufficient descriptive works are already obtainable by the ordinary student, but, limiting the treatment of these to local and economic relations, to monograph those groups which have not been thoroughly studied elsewhere.

In short, it is intended that the school or private library which contains the ordinary works on natural history, to be had by everyone at slight expense, and contains also the publications of this Laboratory, shall have a sufficient working library of the zoloögy and botany of the State, for either practical or ordinary educational purposes. For the accomplishment of this end, so greatly to be desired, little more is needed than the opportunity and funds to enable us to put into print the data with which the shelves, cases and notebooks of the Laboratory are now crowded. When this purpose is well accomplished, a solid and enduring foundation will be laid for the education of the people of this State in the most fundamental and essential part of these important branches of knowledge.

Respectfully submitted,

S. A. FORBES, Director.

FINANCIAL REPORTS OF THE BOARD OF EDUCATION OF THE STATE OF ILLINOIS.

ILLINOIS STATE NORMAL UNIVERSITY, FOR THE TWO YEARS ENDING JUNE 30, 1881, AND JUNE 30, 1882.

<i>Receipts—1880-81.</i>			
Balance on hand July 1, 1880.....	\$873 68		
Appropriations for current expenses.....	22,493 56		
Hay crop on grounds.....	41 00		
Rent of land.....	175 00		
Tuition from model school.....	3,952 22		
Amount due treasurer June 30, 1881.....		\$27,535 46	359 40
		\$27,894 86	
<i>Expenditures—1880-81.</i>			
Advertising.....	\$69 36		
Books and stationery.....	188 90		
Book-keeping.....	130 00		
Chemical laboratory.....	251 30		
Clerical work.....	100 00		
Contingent expenses.....	550 00		
Contingent expenses of committee on building and grounds.....	316 60		
Expenses of Board of Education.....	549 50		
Fuel.....	792 60		
Furniture.....	21 25		
Hauling water for boiler.....	36 80		
Improvement of grounds—drainage.....	37 50		
Janitor's supplies.....	25 76		
Laboratory of natural history.....	249 12		
Labor.....	275 18		
Library.....	300 00		
Printing.....	395 72		
Postage.....	22 80		
Repairs.....	1,765 36		
Salaries.....	21,492 86		
Special land receipts fund—reserved.....	265 00		
Supplies for classes.....	4 25		
Telephone.....	55 00		
		\$27,894 86	
<i>Receipts—1881-82.</i>			
Appropriation for current expenses.....	\$17,500 00		
Discount.....	75		
Rents.....	549 50		
Tuition from model school.....	4,206 91		
Balance due treasurer June 30, 1882.....		\$22,257 16	5,186 70
		\$27,443 86	
<i>Expenditures—1881-82.</i>			
Advertising.....	\$100 00		
Books and stationery.....	154 09		
Chemical laboratory.....	450 00		
Contingent fund.....	550 00		
Contingent expenses of committee on building and grounds.....	141 15		
Chandeliers for hall.....	78 00		
Diplomas.....	90 00		
Expenses of Board of Education.....	436 50		
Fuel.....	742 00		
Furniture.....	54 30		
Janitor's supplies.....	70 22		
Labor.....	109 27		
Physical apparatus.....	450 00		
Postage.....	10 61		
Printing.....	268 34		
Repairs.....	508 71		
Salaries.....	22,871 27		
Balance due treasurer June 30, 1881.....		\$27,084 46	359 40
		\$27,443 86	

**STATE LABORATORY OF NATURAL HISTORY FOR THE TWO YEARS ENDING JUNE 30, 1881, AND
JUNE 30, 1882.**

Receipts—1880-81.

Balance from last report.....	\$386 75	
Appropriation for supply of State museum.....	1,000 00	
" supply of State educational institutions.....	250 00	
" supply of public high schools.....	250 00	
" investigation of food of birds.....	200 00	
" investigation of food of fishes.....	150 00	
" publication of bulletins.....	250 00	
" library.....		
" new books.....	1,000 00	
" cataloguing.....	100 00	
" pay of assistant.....	800 00	
Contingent sales.....	3 00	
		\$4,389 75

Expenditures—1880-81.

State Museum—			
For collecting apparatus and materials.....	\$94 75		
" laboratory expenses.....	57 85		
" entomological materials.....	2 29		
" herbarium materials.....	48 80		
" skins and skeletons of animals.....	21 25		
" work on fish casts.....	59 25		
" purchase of specimens.....	10 12		
" pay of taxidermist.....	175 00		
" assistance.....	196 60		
" incidentals and traveling expenses.....	128 08		
" transportation.....	101 35		
" packing boxes.....	45 20		
			\$940 54
State Educational Institutions—			
For collecting apparatus and materials.....	\$69 20		
" laboratory expenses.....	10 70		
" purchase of specimens.....	59 74		
" pay of taxidermist.....	80 00		
" assistance.....	16 00		
" transportation.....	1 75		
			237 39
Public High Schools—			
For collecting and traveling expenses.....	\$74 05		
" laboratory expenses.....	76 32		
" assistance.....	10 50		
" transportation.....	52 58		
" cans and packing boxes.....	15 75		
" printing.....	2 75		
			231 95
Investigation of Food of Birds—			
For collecting apparatus and materials.....	\$51 78		
" field expenses.....	58 00		
" laboratory expenses.....	12 00		
" purchase of specimens.....	65 70		
" assistance.....	12 36		
" transportation.....	1 55		
			204 39
Investigation of Food of Fishes—			
For collecting apparatus and materials.....	\$45 30		
" field expenses.....	19 30		
" laboratory expenses.....	44 30		
" assistance and labor.....	19 36		
" transportation.....	11 55		
			139 81
Publication of Bulletins—			
For printing of Bulletin 3.....	\$320 82		
" printing of Bulletin 4, in part.....	100 00		
" miscellaneous.....	7 50		
" postage, stationery and traveling expenses.....	9 00		
			437 32
Library—			
For books.....	\$1,017 18		
" books (omitted from last report).....	187 87		
" binding.....	77 85		
" cataloguing.....	140 45		
			1,423 35
Pay of assistants.....			775 00
			\$4,389 75

STATE LABORATORY REPORT—Continued.

RECEIPTS—1881-82.			
Appropriation for field work in zoölogy	\$700 00		
“ for field work in botany	500 00		
“ for supply of State Museum	400 00		
“ for supply of State educational institutions	100 00		
“ for supply of public high schools	100 00		
“ for investigation of food of birds	100 00		
“ for investigation of food of fishes	50 00		
“ for investigation of parasitic plants and animals	200 00		
“ for improvement of library	800 00		
“ for pay of assistants	800 00		
“ for office and incidental expenses	350 00		
“ for publication of bulletins	400 00		
			\$4,500 00
EXPENDITURES—1881-82.			
Field Zoölogy :			
For field expenses of collecting parties	\$446 40		
For field apparatus and materials	205 37		
For transportation	12 05		
For labor	68 50		
			\$732 32
Field Botany :			
For field expenses of collecting parties	\$225 75		
For transportation	24 60		
For purchase of specimens	12 60		
For botanical assistants	290 02		
			552 97
State Museum :			
For purchase of specimens	\$146 90		
For expenses of collection and travel	120 08		
For freight	2 39		
For pay of assistants engaged in museum work	130 00		
			425 62
Public High Schools :			
Collection of specimens	\$45 00		
Transportation	31 95		
Shipping expenses	12 00		
			88 95
State Educational Institutions :			
Pay of collector			120 00
Investigation of Food of Birds :			
For purchase of specimens	\$32 50		
For expenses of collecting birds	75 10		
			107 60
Investigation of Food of Fishes :			
For expense of collections			60 90
Investigation of Parasitic Animals and Plants :			
For apparatus and materials	\$31 60		
For transportation	4 25		
For special assistance	169 85		
			205 70
Library :			
For purchase of books	\$664 51		
For binding	68 95		
For transportation	6 80		
For cataloguing	115 53		
Miscellaneous	16 70		
			872 49
Publication of Bulletins :			
For printing			44 43
For pay of Assistants			847 20
Incidental and Office Expenses :			
Stationery, postage, telegrams and money orders	\$52 23		
Apparatus and materials	162 03		
Transportation	30 34		
Purchase of specimens	7 80		
Printing	7 00		
Travel on Laboratory business	35 00		
Labor	18 35		
Repairs	30 00		
Small Laboratory expenses	36 95		
			379 70
Balance			441 82
Total expenditures and balance			\$4,500 00

REPORT

OF THE

DIRECTOR

OF THE

STATE LABORATORY OF NATURAL HISTORY,

CHAMPAIGN, ILLINOIS.

JUNE 8, 1887.

CHAMPAIGN, ILL.:
GAZETTE STEAM PRINT.

1887.



To the Trustees of the University of Illinois:

GENTLEMEN: At the meeting of the Trustees of the University held in July, 1885, it was

Resolved, That it is the sense of this Board that the Director of the State Laboratory of Natural History should make quarterly reports to this Board, through the Regent of the University, of the affairs and operations of the laboratory under his charge.

Heretofore, observing, perhaps, the spirit rather than the letter of this resolution, I have endeavored to make you acquainted informally with our operations each quarter, so far as was necessary to your intelligent action on the requests which I have from time to time submitted to you; but I have not made to you systematic quarterly reports on the details of our work. I have lately concluded, however, that more should be known by the public interested, with respect to the scope, purpose, and results of the operations of the State Laboratory of Natural History; and as one means to an improvement of our position in this respect, I have decided to avail myself of the resolution cited above, and to file with you, for your information, an outline of our plan of operations and of the work accomplished each quarter.

The work of the Laboratory is two-fold, relating on the one hand to the natural history survey of the State (finally authorized and organized by the Legislature of 1884-85), and on the other, to the State Entomologist's Office, the working funds of which are all derived, under existing arrangements, from the Laboratory appropriations. As State Entomologist, I am directly responsible only to the Governor; but the entomological and the general zoological work going on under my charge are so intimately blended that I cannot well report upon one without including the other; and as both are now supported by State appropriations administered by this Board, I have thought best to include both in this statement.

The principal operations of the State Laboratory conveniently divide into *original investigation*, and the *preparation and publication of papers, bulletins, and reports*. We have been especially engaged during the last quarter upon the following subjects:

(1) The life history of the Hessian fly. This is in continuation of the research begun last year on the midsummer and winter history of this species, by means of experimental sowings of wheat made at intervals throughout the summer in southern Illinois. By observing the appearance of the insects in these experimental plots and following the history of the various lots through the winter and

spring, we have ascertained facts which promise important measures for the control of this pest. Field experiments with remedies based on this new knowledge will be made this summer in the southern part of the State.

(2) The life history of the corn plant louse. By field observations and office breeding experiments we have now cleared up the winter history of this species,—a point upon which nothing has heretofore been known. Similar methods will doubtless give us this season the data for a full life history of this pest of the corn fields.

(3) The life history and species of various corn cutworms. By breeding experiments with the various cutworms affecting corn, we expect to determine the species of these larvæ, and also the precise period when each ceases its destruction in the field,—a matter of economic interest, because it must fix the time when replanting corn destroyed by these insects will be profitable.

(4) The life history of certain Tipulid larvæ, which have this year proved to be exceedingly mischievous in meadows and pastures. This subject has already been brought to satisfactory conclusion.

(5) Field and laboratory experiments for the control of the ravages of the root web worm,—an insect recently discovered, which has this year done great and wide-spread injury to young corn.

(6) Orchard experiments with lime for the prevention of damage to apples by the codling moth.

(7) Field experiments in southern Illinois to test the influence of various fertilizers in supporting the farm crops against the attacks of the chinch bug. Other experiments for the protection of the corn crop against this insect will be begun this month.

(8) Elaborate studies of the contagious diseases of insects—especially of the silkworm, army worm, and the various cutworms, together with experiments for the artificial production of these diseases.

(9) Studies of the animal life of the lakes of Illinois, for which we are systematically working over the large collections made while we were at Normal, and putting the data accumulated in shape for publication.

(10) Of a different character are some personal studies of the minute anatomy of blind Crustacea as compared with those having the power of vision,—a study which we have here an unusual opportunity to pursue, since these eyeless forms are very abundant in our subterranean waters.

(11) Studies made by Professor Garman on the minute anatomy of peculiar forms of earthworms common in this region.

(12) Collections and studies of a family of leaf mites (Phytiopti) injurious to vegetation, which Professor Garman is also carrying forward.

(13) Studies of certain families of parasitic Hymenoptera and of harvestmen (Phalangidæ), which Mr. Weed is making.

(14) Miscellaneous breeding cage experiments on the life his-

tories of insects, largely of economic species, made chiefly by Mr. Hart and Mr. Weed.

To this list I should perhaps add the routine work of the office in the collection of specimens, especially of insects, and in the labeling, determination, and arrangement of the insect collections which have accumulated in the office,—a work which falls especially upon Mr. Hart.

Here I ought also to mention the studies made, at the expense of the Laboratory appropriations, by Professor Burrill and his assistant, on certain families of the parasitic fungi of the State,—a work preliminary to the preparation of papers for our bulletins and the final report on the cryptogamic botany of Illinois.

The field work of the Laboratory and office has fallen chiefly to myself and Mr. Weed. It has covered all parts of the State, from Cairo to Galena, but has mostly been done in southern Illinois, where the situation this year is of peculiar interest. The various trips made since last March aggregate 2500 miles of travel.

Our *publications* comprise four series; the regular entomological reports, the bulletins of the entomological office, the bulletins of the State Laboratory of Natural History, and the State zoological report. The papers and reports recently prepared and published, or now in course of preparation, are as follows:

(1) The 15th Report of the State Entomologist of Illinois, now practically finished and awaiting the orders of the State Board of Contracts.

(2) A general account of the lake fauna of Illinois, delivered as an address to the Peoria Scientific Association and published in the Bulletin of that Association this year, and also in an emended edition, as a separate

(3) A general article on contagious insect disease read as a presidential address to the Entomological Club of Cambridge, Massachusetts.

(4) A special article on the same topic—the second of a series—containing the results of our investigations and experiments on this subject for the last two years.

(5) An elaborate report on the experiments of last year with arsenical poisons for the codling moth in the apple orchard, published as a bulletin of the office. The first edition of five hundred copies of this bulletin was soon exhausted and a second was issued.

(6) We have likewise published and distributed widely two general circulars on the chinch bug in southern Illinois.

(7) I have also prepared two addresses to farmers' institutes—on insects injurious to corn, and on apple insects—and have delivered one or the other of these addresses at eight farmers' institutes during the winter and spring.

(8) A descriptive paper prepared by Mr. Weed, on certain parasites of the insects of the apple orchard, is now in press as one of the articles of the Laboratory bulletin.

(9) We have also on hand, ready for publication, an illustrated synopsis of one of the families of the Homoptera of Illinois (Jassidæ), by Mr. C. W. Woodworth, a former assistant in the office.

(10) A monograph on one of the families of the parasitic fungi of the State (Erysipheæ), by Professor Burrill and Mr. F. S. Earle, has been finished during the quarter and is now in press for the bulletin of the Laboratory.

(11) Professor Burrill has also nearly ready for printing, reports on two other families of Illinois fungi (Ustilagineæ and Peronosporæ).

(12) The first volume of the zoological report, covering the entire ornithology of the State, has been long in press, but makes very slow progress, because two copies of the proof of the part now printing must go successively to Washington. The four hundred and thirty-second page has now been reached by the printer.

The additions to the equipment of the Laboratory, made during the last quarter, are not especially important, but are confined chiefly to the usual increase of the library and to several pieces of the apparatus of microscopy and bacteria culture.

During the coming summer, besides carrying forward the economic work of the entomological office on the largest scale which our resources will at all permit—giving especial prominence to field experiment (a new feature of our work)—I hope also to make decided progress in our knowledge of the aquatic life of the State—especially in its lowest forms—and for that purpose expect to establish temporarily a station on one of the lakes of northern Illinois, fully equipped from the Laboratory for careful and thorough aquatic work.

Beyond the customary routine action on the appropriations of the Laboratory, I have no especial requests to make of the Board at this meeting.

Respectfully submitted,

S. A. FORBES, Director of Laboratory.

June 6, 1887.

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BIENNIAL REPORT

OF THE

DIRECTOR

OF THE

STATE LABORATORY OF NATURAL HISTORY,

CHAMPAIGN, ILLINOIS.

OCTOBER 31, 1888.

BIENNIAL REPORT OF THE ILLINOIS STATE LABORATORY OF NATURAL HISTORY.

STEPHEN A. FORBES, PH. D., DIRECTOR.

Dr. S. H. Peabody, Regent of the University.

SIR: In accordance with the suggestion of the Committee on Publication, I have the honor to transmit herewith to the Trustees of the University, for publication in their biennial report, a statement of the operations of the State Laboratory of Natural History, under my direction, for the two years closing October 31, 1888,—this being substantially a summary of the quarterly reports made to the Board at their regular meetings.

The work of the Laboratory is twofold, relating on the one hand to the natural history survey of the State (formally authorized and organized by the Legislature of 1884-85), and on the other, to the State Entomologist's Office (established in 1867), the working funds of which are all derived, under existing arrangements, from the Laboratory appropriations. As State Entomologist, I am directly responsible only to the Governor; but the entomological and the general zoological work going on under my charge are so intimately blended that I cannot well report upon one without including the other; and as both are now supported by State appropriations administered by this Board, I have thought best to include both in this statement.

ORGANIZATION.

The working force of the Laboratory for the past two years has included a Director, serving without salary;* a botanist, Prof. T. J. Burrill; a botanical assistant, Mr. M. B. Waite; a zoological assistant, Prof. W. H. Garman; two entomological assistants, one especially assigned to field work, Mr. C. M. Weed, succeeded by Mr.

*The item of \$2,000 per annum appropriated as salary of the Director of the Laboratory (Laws of Illinois, 35th General Assembly p. 71, Sec. 1) is not drawn or available as long as that officer is also State Entomologist. (Laws of Illinois, 34th General Assembly p. 24, Sec. 4.)

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John Marten, and one to office entomology, Mr. C. A. Hart; an amanuensis, Miss M. J. Snyder; and a janitor. Drawing and other miscellaneous assistance is variously provided for according to circumstances.

Our operations may be conveniently reported under the heads, Investigation, Office Work, Publication, and General Educational Work.

INVESTIGATION.

The original investigations of the Laboratory now run along three general lines, never wholly distinct, but still usually distinguishable,—those of general zoology, entomology, and cryptogamic botany.

General Zoology.

Our researches in general zoology have been chiefly directed, during the past two years, to the aquatic animal life of the State, which we are studying systematically both in detail and as a whole, working at the identification, description, and illustration of the species; at their distribution, haunts, food, and habits; at their relations to each other where they are thrown together, as in the same lake or stream; at their relations to nature generally, as determined by climate, season, quantity and quality of water, and the like; and at their relations to man as affecting the maintenance and increase of the food supply derived or derivable from the waters of the State,—aiming thus to present finally a picture of the aquatic life of Illinois, both plant and animal, in a form suited to attract the interest of the intelligent citizen, to instruct the student, and to contribute to the economic welfare of the State. Our work in this direction has lately come into close and, I hope, mutually helpful relation to that of the State Fish Commission, as I shall show more fully when reporting upon the investigations of the present season.

Field work on our aquatic zoology has fallen chiefly to Prof. Garman, Mr. Hart, and myself. In 1887 we thoroughly studied several of the smaller lakes of northern Illinois, and one of us spent a fortnight on one of the larger lakes of southern Wisconsin, making soundings, dredgings, and surface-net collections for comparison with those from the smaller lakes of the same series in our own State.

Large collections illustrative of the food of fishes were made at Quincy and Havana the latter part of the summer by Prof. Garman and myself, the material thus obtained enabling me to

bring to a conclusion the general study of that subject, which I have had in hand since 1880.

Beginning in November, 1887, surface-net collections have been made twice a week for the Laboratory from the waters of Lake Michigan, off Chicago, (except when the ice prevented,) to enable us to follow the succession, development, and relative abundance, at different seasons, of the forms of animal life upon which we have found the young of the principal food fishes to be strictly dependent.

During the season of 1888 we have had extraordinary opportunities for aquatic work afforded us by the State Fish Commission through its Secretary, Mr. S. P. Bartlett. Lack of time and assistance prevented my taking as much advantage as I would have been glad to do of the facilities generously placed at our disposal; but a good beginning was made in July and the latter part of August on a more systematic and thorough-going survey of the life of our waters than we have heretofore been able to undertake. Working from the wharf-boat of the Commissioners as head-quarters and usually accompanying their field parties, but with boats and assistants under his own control, Prof. Garman made an especially careful examination of those waters from which young fishes were being taken for distribution throughout the State, studying the plant and animal forms of such situations, noting the size, depth, condition, and surroundings of the bodies of water visited, and collecting all information of every description which could aid us in the preparation of a full and exact account of the assemblage of forms and the system of life exhibited. We learned from these studies enough to show the very remarkable and far-reaching differences occasioned here by differences of situation with respect to the amount and period of overflow, and to fully open up to us this inviting subject of investigation as affecting all the river systems of the State. A general report on this work, made with principal reference to its relations to the operations of the State Fish Commissioners, is now in course of preparation, and will be submitted to them when finished. A more detailed exhibit of the scientific results will be published in the Bulletin of the Laboratory.

I hope to have hereafter the funds and assistance to carry studies of this description steadily forward through all the working season, moving the field head-quarters from place to place as circumstances may require.

Good progress has been made at the Laboratory in the study and description of all our recent aquatic collections.

Under the head of general zoology comes my own personal study of the food and feeding habits and structures of several families of our fishes,—to which much time was given in the winter of 1887-88,—and the preparation of a general summary and discussion of the whole series of papers on this topic published by me since 1880.

Minor labors in the same general field are a study of the species of harvestmen (*Phalangidæ*) of Illinois by Mr. Weed, on the anatomy and histology of certain crustaceans of subterranean habit by myself, and on the leaf mites of the State by Prof. Garman.

Entomology.

The entomological work of the past two years has been almost wholly economic in its objects, but incidental to the study of insect injuries to agriculture, a considerable mass of information and material has been accumulated, of more general entomological interest.

The purely economic work has been extraordinarily heavy and exacting, due especially to a wide-spread and very destructive outbreak of the chinch bug, now but just disappearing. We have kept the infested area, both in southern and northern Illinois, under inspection during the whole two years, making repeated visits to selected localities for comparative observations in the field. At Edgewood, in Effingham county, and at Tonti, in Marion county, we have conducted field experiments for the protection of wheat against chinch bug injury—in the former instances with great success, in the latter with only partial results, owing to the winter-killing of the grain. At the office we have made numerous tests and experiments with insecticides.

During the summer and autumn of 1888, we have collected a very large amount of information from every part of the State concerning the effect on the chinch bug of different crops and combinations of crops, with especial reference to wheat culture, and have collated, tabulated, and discussed this information, deriving from it important practical generalizations with respect to farm management during the progress of a chinch bug uprising.

We have also diligently studied three forms of contagious disease to whose virulent activity in the southern part of the State is chiefly due the rapid disappearance of the larger part of the chinch bug hosts infesting that region,—a difficult and laborious research which is still in progress.

Next to the chinch bug, the Hessian fly and the corn plant louse

have received the largest share of our attention. During both summers periodical sowings of wheat were made in southern Illinois on selected plots, from harvest to the usual seeding time in fall, to determine more precisely the summer history of the fly. Those of 1887 failed because of the extreme drouth, but those of 1888 confirmed the results of similar experiments made by us in 1886. Office experiments with this insect are now in progress.

The corn plant louse we have studied by careful field observation and by continuous breeding experiments in the laboratory, made especially during fall and spring. These experiments have determined the spring and winter history of the root louse; and others made by enclosing hills of corn in the field with large gauze-covered frames have thrown much light on the midsummer history and breeding habits of this species. We are now carrying this insect through the winter in the botanical conservatory under conditions to give us additional information concerning it. Colonies of the small brown ant to whose ministrations these plant lice are especially indebted, have been artificially reared and regularly observed through the season to determine their life history and habits.

Several species of our cutworms have been bred by us for the first time,—one, phenomenally destructive this year throughout the whole State, never before identified nor noticed.

We have made, both years, studies of the web worms injuring corn and grass lands, with experiments for their destruction.

In the spring and early summer of 1888 we made many elaborate experiments with insecticides for the destruction of wireworms in corn.

In 1887 the life history and habits of an insect destructive to meadows,—the larva of one of the crane flies not before known as injurious,—was ascertained by field and laboratory observations; studies were made of some of the insects most injurious to nursery stock; additional experiments were conducted for the control of injuries to fruits by the codling moth; the life history, species, and habits of a new plum borer were determined; considerable systematic and biological work was done on a large number of plant louse species, and an elaborate research was carried forward on the contagious diseases of the army worm, several species of cutworms, and the cabbage caterpillar.

In 1888 we also learned the habits, development, and history of a large snout beetle responsible for a frequent and extensive injury

to corn not before understood, and discovered means of avoiding its ravages; and made elaborate studies, by the method of dissection, of the food and feeding habits of the snout beetles generally, throwing light, by this means, on the most serviceable measures for preventing their injuries to fruit.

Botanical Work.

Studies of the fungi of Illinois—principally those known as parasites,—causes of disease among plants and animals,—have been carried continuously forward, chiefly, as heretofore, under the immediate charge of Prof. T. J. Burrill. Large collections have been made during the past two years, chiefly by the botanical assistant, Mr. Waite, in Edwards, Wabash, Ogle, Lake, and Carroll counties; and work of this description has gone forward, almost without intermission, in the neighborhood of the Laboratory.

An extremely destructive disease of broom-corn and sorghum, due to bacterial infection, has been thoroughly worked out by Prof. Burrill, and measures of avoiding its attack have been discovered; and a study is well under way of a similar but more important disease of Indian corn, found by us widely prevalent from Edwards county to Kankakee county.

Careful and elaborate studies are also in progress of the bacteria and other plant parasites which we have found to cause contagious disease among insects,—those of the chinch bug having been investigated with especial thoroughness.

OFFICE WORK.

The office assistants have been chiefly engaged on the correspondence, in the preparation of the manuscript for the entomological report and for the bulletins published since 1886, in proof reading of these and of the volume on the ornithology of the State,—the latter read twice because once destroyed by fire,—in the cataloguing and indexing of new books and periodicals received, in the preparation of two elaborate bibliographies,—one including all the entomological writings of our first two State Entomologists, Walsh and LeBaron, and the other covering the literature of the chinch bug,—in making the numerous charts, diagrams, and drawings used in illustration of lectures—especially those to farmers' institutes; in collecting from nearly nine hundred township assessors the facts concerning chinch bug injury to the principal farm crops, in acting from the assessors' reports for 1887 the acreage in each

crop for all townships in the State, and in collating and tabulating this mass of information—a work which occupied the time of two assistants for many weeks of the present summer and autumn.

Under this head should also come the care of the entomological breeding room by Mr. Hart, the preparation, determination, and arrangement of the thousands of specimens collected, and the keeping of the voluminous records, catalogues, and indexes of collections.

PUBLICATIONS.

Our regular publications run in four series, two from the Laboratory and two from the Office of the State Entomologist,—the former comprising the State zoological report and the bulletins of the State Laboratory of Natural History, and the latter the biennial entomological report and the bulletins of the entomological office.

During the past two years we have finished the printing of the first volume on the zoology of the State,—containing five hundred and twenty pages of text and forty-six plates,—devoted to the ornithology of Illinois as far as the water birds. This is a reprint of the volume, the first edition having been entirely destroyed in the burning of the office of the State Printer last February.

As bulletins of the State Laboratory of Natural History we have issued an article on one of the families of parasitic fungi of the State (*Erysipheæ*) by Prof. T. J. Burrill and Mr. F. S. Earle, (forty-five pages,) two papers by myself on the food and feeding habits and structures of alimentation of the fishes of Illinois (one hundred and five pages), one by Prof. H. Garman on the anatomy and histology of a new genus of earthworm (thirty pages), one by Mr. C. W. Woodworth on the classification of one of the families of homopterous insects of the State (twenty-four pages), and two papers on insect parasites by Mr. C. M. Weed, (fourteen pages).

The entomological report for 1885–86 has lain unpublished to the present time, caught in the general obstruction of the public printing growing out of the State-printing controversy, but is understood to be now in press.

As bulletins of the entomological office, we have issued an elaborate report on the experiments of the years 1885–86 with arsenical poisons for the codling moth in the apple orchard, an article on the chinch bug outbreak, with recommendations for its control, and an article on the life history of the Hessian fly, setting forth the results of our field experiments on the subject. We have also issued several entomological circulars not of any series.

Articles written at the Laboratory, but published elsewhere, include a paper on the present state of our knowledge concerning contagious insect diseases, prepared as a presidential address for the Entomological Club of Cambridge, Massachusetts, and published in "Psyche," the organ of the Club; a paper on the food of the fishes of the Mississippi Valley, read at the Seventeenth Annual Meeting of the American Fisheries Society in Detroit, Michigan, and published in their "Transactions" and also as a separate pamphlet; a paper on the relations of wheat culture to chinch bug injury, read at the Cleveland meeting of the Society for the Promotion of Agricultural Science and published in their "Proceedings;" an address as president of the Western Naturalists' Association, delivered at Champaign and published in the "American Naturalist;" four papers for the State Horticultural Society by myself and Mr. Weed, printed in the annual volumes of the Society; three technical entomological articles by Mr. Weed and two by myself, printed in "Psyche" and *Entomologica Americana*; and a considerable number of articles written for the agricultural papers in response to inquiries from their editors. Here also should be mentioned an article by Prof. Burrill, giving the results of his study of the broom-corn disease already referred to,—this paper being published in the Proceedings of the Society of American Microscopists for 1887.

GENERAL EDUCATIONAL WORK.

Among addresses made by the office force but not regularly published, are seven on entomological topics, prepared for farmers' institutes and delivered twenty-six times in all; one on the chinch bug, delivered six times before county conventions called to adopt measures for joint action against that insect pest; two on educational topics before the State Teachers' Association and the Teachers' Association for Central Illinois; and one read to the Peoria Scientific Association and at the commencement exercises of the State University of Indiana.

RELATIONS TO THE AGRICULTURAL EXPERIMENT STATION.

The recent organization, at the University, of the State Agricultural Experiment Station has raised the question of the relations of the work thus instituted to that of the Natural History Laboratory and the State Entomologist's Office with the effect to bring about an adjustment of the two at their points of contact in cryptogamic botany and economic entomology. The purpose of the State Laboratory being essentially scientific and educational, its results are

only incidentally economic; while the purposes of the Experiment Station are essentially economic, and its scientific work must naturally be regulated with close reference to practical results. In cryptogamic botany, for example, the Laboratory is engaged in a general survey of the State intended to give us the species, the classification, and the life histories of all our flowerless plants, whether economically important or not, and the relations of these to agriculture will come in as a purely secondary matter; while in Experiment Station work, on the other hand, little attention will probably be paid to any species except those having economic relations. All practical botanists are agreed, however, that the economic species and those of no economic importance are so intimately related in classification, habit, and life history, that a full and exhaustive knowledge of the whole subject is very helpful, and often indispensable, for the solution of merely economic problems. The more, in short, the State Laboratory is able to do in technical and biological botany, the easier and more fruitful will be the economic work of the botanical department of the Station. The former should, in fact, supply a broad and strong foundation on which the latter may build elaborately.

As much of the work in the two directions requires substantially the same facilities, methods, skill, and knowledge, the two may be easily combined in a way to economize labor and expense and to increase results, the only requisite being a common scheme of subdivision and adjustment of subjects of research, and a proper arrangement with respect to assistance, separate and conjoint, in the two departments.

Substantially the same may be said of the entomological work, except that here the State has provided fairly well, for many years, for both scientific and economic entomology. The line of division and co-operation naturally suggested is that of the practical application in the field, of economic results obtained in the office. This is so essential a part of our economic work that I have felt compelled to take it up, and have conducted in southern Illinois several field experiments relating to insect injuries to wheat. But this field experimentation does not properly belong to entomology; it is very expensive in time and money; and I shall be glad to be wholly relieved from it. On the other hand, I have undertaken to determine insects referred to me as of economic interest by those engaged in the Experiment Station work; to study their life histories; and to make office experiments with respect to them, as far as our resources will

permit, reporting results for such verification in the field as may seem to be required.

NEEDS OF THE WORK.

For the future we need especially an entomological laboratory, that we may conduct our experimental work on a larger scale and under conditions completely under our control. The necessity we are now under for traveling one hundred and fifty miles every time we wish to make an observation on the Hessian fly or the chinch bug, because we cannot arrange breeding frames large enough to contain a sufficient number of these insects and their food; and our failure, after four years' work, to make out some of the indispensable points in the life history and habits of the corn plant louse because we have no sufficient means of keeping this species under observation without exposing our specimens to conditions so unnatural that they soon perish, are illustrations of the disadvantages under which we work. To supply this lack I shall have to ask from the Legislature an appropriation of \$1000 for the erection and furnishing of a suitable building for the breeding of insects, the rearing of their food plants, and other experimental work of this description. Otherwise, the appropriations now required need not vary materially from those made at the last session of the Legislature.

Respectfully submitted,

S. A. FORBES,

Director of Laboratory.

October 31, 1888.

BIENNIAL REPORT
OF THE
DIRECTOR
OF THE
ILLINOIS STATE
LABORATORY OF NATURAL HISTORY
CHAMPAIGN, ILLINOIS
1889-1890

J. W. FRANKS & SONS
PRINTERS, BINDERS AND ENGRAVERS
PEORIA, ILLINOIS

BIENNIAL REPORT OF THE ILLINOIS STATE LABORATORY OF NATURAL HISTORY.*

Dr. S. H. Peabody, Regent of the University:

SIR: In accordance with the spirit (although, I must confess, not strictly with the letter) of a resolution adopted by the Trustees of the University July 1, 1885, to the effect that the Director of the State Laboratory of Natural History should make to the Trustees, through the Regent, quarterly reports of the affairs and operations of the Laboratory, I beg to offer this report of our affairs during the last two years.

The organization of this establishment and its operations during this time have differed but little in scope and general character from those reported to the Trustees in 1888.†

The staff of the Laboratory during the last two years has consisted of a botanist, Prof. Burrill,—engaged for only a small part of his time; a botanical assistant, alternately Mr. Moses Craig and Mr. G. P. Clinton; an office entomologist, Mr. C. A. Hart; a field entomologist, Mr. John Marten; a zoölogical assistant, Mr. H. S. Brode (giving the Laboratory such part of his services as were not appropriated by the University); an amanuensis, Miss M. J. Snyder; and an artist, Mr. A. M. Westergren, employed in drawing (chiefly entomological) for only seven months. The salaries of those whose time is divided between the Laboratory and University are derived in part from each source, in amounts proportioned as nearly as may be to their services for each. The botanist has received from the Laboratory \$200 a year, the botanical assistants full pay for time actually spent on Laboratory work, and the zoölogical

* For financial statement for the two years ending June 30, 1890, see Fifteenth Report of the Board of Trustees of the University of Illinois, pp. 92, 177.

† See Fourteenth Report of the Board of Trustees of the University of Illinois, p. 185.

assistant \$100 for the present year only. The salaries of the office entomologist, field entomologist, and amanuensis (who acts also as librarian) have been, respectively, \$600, \$900, and \$600.

Owing to changes of assistants, indirectly due to the organization of a large number of new state agricultural experiment stations, the general zoölogical work of the State Natural History Survey has materially fallen off, but relatively greater attention has been given to economic investigation. The zoölogical work has been limited to considerable additions to the ornithological collections, made for a further study of the food of birds; and desultory studies on the lower aquatic animals of the state, especially insect larvæ, Vermes, and Protozoa. The progress of our knowledge of the aquatic zoölogy of Illinois has been indirectly advanced by vacation work done outside our state limits,—during the summer of 1889 in northern Michigan and Lake Superior, and during that of 1890 in the lakes and streams of the northern Rocky Mountains. Reports on these collections have been prepared, or are in course of preparation, for publication by the U. S. Fish Commissioner, and as this material is studied, our similar and parallel collections from this state are studied with it, to the great advantage of the local work.

Our entomological investigations have been, as heretofore, almost wholly economic in their motive; nevertheless, no opportunity has been lost to improve our acquaintance with the insects of Illinois, whether economically interesting or not. The building of an insectary and separate office (the former devoted to experimental work upon the life histories of insects, their injuries to vegetation, and methods of practically controlling them) has given us an opportunity not before enjoyed for continuous observation and accurate experiment on some of the most difficult species. The principal subjects which we have studied are the life histories of cutworms, the contagious diseases of the chinch bug, the life history of the corn root louse and of the species of ant uniformly associated with it, the feeding habits of the plum and peach curculio with insecticide experiments for its destruction on the peach, the stages and life history of a new plum borer, the injuries to fruit by the

common Thrips or strawberry "midget," the injuries and life history of the little-known corn root worm, the spring and summer history of the Hessian fly, and the life histories of the common white grubs and wireworms. Other subjects of interest studied are injuries to fruit trees by the European bark beetle, the damage to wheat, oats, and other grains by the grain Aphis, the life history of the swamp bill bug, the species and life histories of a considerable number of gall gnats, and the breeding, identification, and description of common aquatic larvæ from temporary pools in spring. Especially important progress has been made in our knowledge of the history and habits of some of the commonest and most destructive insects of the farm, including the white grubs, the Hessian fly, and the corn root louse.

The entomological collection has been greatly enlarged, especially in Diptera, and a large number of determinations in all orders have been made. The named collection is now contained in 160 double boxes, and numbers about 5,000 species, each being represented, as a rule, by four selected specimens. The pinned and determined duplicate insects on hand—largely in process of distribution to public schools—amount to 42,600 specimens. The alcoholic insects, including large numbers of larvæ, are contained in about 10,200 bottles and vials.

Seven hundred and forty-four copies of the zoölogical volume—the first on the ornithology of the state—have been issued up to the present time (Dec. 31, 1890), 732 of them gratuitously, 656 in Illinois and 76 outside of the state, and 12 have been sold at cost (\$3.50 a volume). There remain of the edition printed 256 copies, 200 of which we have reserved for future use.

There have been printed since my last statement two of my reports as State Entomologist, that for the years 1885 and 1886—long delayed in the hands of the printer—having finally been issued in 1889, and the report for 1887 and 1888, in 1890. Each of these reports contains seven articles; the first 103 pages and the second 226 pages.

In the Bulletin of the Laboratory six articles have been issued in the last two years, one on the animals of the Mississippi bottoms, by Prof. H. Garman; two by myself, describing

new species of Vermes; two by Mr. Weed, on the "harvest-men" of Illinois; and one by Prof. Garman, on Illinois reptiles and amphibians — 110 pages in all.

Other articles prepared at the Laboratory during the period covered by this report, but published elsewhere, are as follows: "Note on Chinch-Bug Diseases," "Early Occurrence of the Chinch Bug in the Mississippi Valley," "Arsenical Poisons for the Plum and Peach Curculio," "Office and Laboratory Organization," "History and Status of Public School Science Work in Illinois," "New and Old Insects," and a "Synopsis of Recent Work with Arsenical Insecticides," by myself, and a description of a new gall-fly by Mr. John Marten.

Other articles prepared by us and now in press, are as follows: "On Some Lake Superior Entomostraca," "Preliminary Report upon the Invertebrate Animals inhabiting Lakes Geneva and Mendota, Wisconsin," "A Summary History of the Corn-Root Aphis," "On the Life History of the White Grubs," and "Report of Progress in Economic Entomology," by myself; "Life History and Immature Stages of Wireworms," by Mr. C. A. Hart; and "New Notes on the Life History of the Hessian Fly," by Mr. Marten.

I have addressed, during the two years, fourteen farmers' institutes in various parts of the state and three horticultural societies, and have also lectured before the Chicago Institute and the Cincinnati Natural History Society.

The accumulation of duplicate insects has reached a point where it is again possible to distribute them to advantage to such public schools as teach regularly the subjects they illustrate. I consequently sent in 1889, a circular of inquiry to a number of these schools, from the replies to which a list of schools was made to which sets of insects will be sent during the winter. The specimens available for this distribution (22,000 in number) will be made up into forty sets and sent out as fast as ready, with lists of names, both technical and common, and a pamphlet of economic notes respecting the species related in any important way to agriculture or horticulture. The amount of work involved in this distribution may be judged in part by the fact that the mere numbering and arrangement of this material in boxes, ready for shipment,

after the labor of collection, preservation, determination, and systematic classification is all done, will take all the time of one assistant for about a month.

Our work of the past two years has been greatly hampered by the insufficiency of our library fund, and the loss of valuable assistants with years of experience on our subjects and training in our methods, and more useful here than any one else could be for a long time to come. This loss was due simply to inadequate provision for their salaries. If this work is to continue on its present basis, it is indispensable that our library appropriation be put back to what it was two years ago, and that sufficient allowance be made for salaries to enable me to hold good assistants in competition with experiment stations and other institutions offering employment to able and well-trained young men.

Respectfully submitted,

S. A. FORBES,

Director of Laboratory.

December 31, 1890.

BIENNIAL REPORT

OF THE

DIRECTOR

OF THE

ILLINOIS STATE

LABORATORY OF NATURAL HISTORY

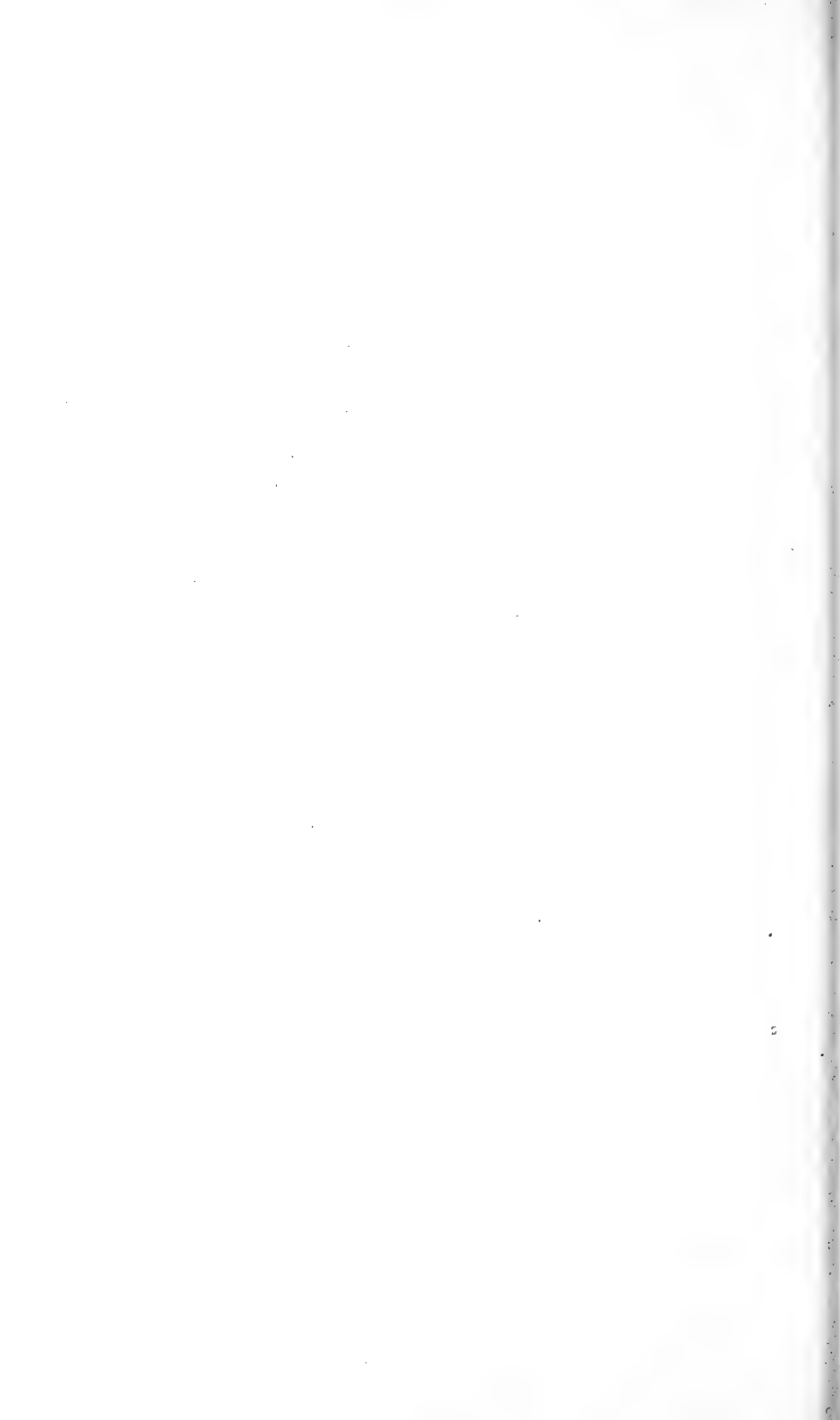
CHAMPAIGN, ILLINOIS

1891-1892.

SPRINGFIELD, ILL.:

H. W. ROKKER, STATE PRINTER AND BINDER.

1892.



BIENNIAL REPORT OF THE ILLINOIS STATE LABORATORY OF NATURAL HISTORY.

To the Trustees of the University :

GENTLEMEN: In conformity to the recommendation of a special committee on the the status of the State Laboratory of Natural History, whose report was made to you June 8, 1892, and in anticipation of your action on that recommendation, I beg to submit the following general report on the operations of the Laboratory during the two years just past.

The functions of the Laboratory, as most recently defined by the legislature, in the law of 1885, are the making of a natural history survey of the State, the supply of natural history specimens to the State museum, the State educational institutions, and the public schools, and the publication of a systematic series of reports on the zoölogy and the cryptogamic botany of the State. Its operations now cover, under authorization of the same law, those of the State Entomologist, which were described by the law establishing that office in 1867 to be the investigation of the entomology of the State (particularly the history of insects injurious to horticulture and agriculture in Illinois), the collection of a cabinet of insects to be deposited in the University of Illinois, and the preparation of biennial reports of the entomological researches and discoveries made at the office.

The work of the establishment is further necessarily guided to a considerable extent by the appropriation laws in force; and by authority of these laws we are publish-

ing, in addition to the two series of reports above mentioned, a third series of miscellaneous articles, containing only original work on the natural history of the State, issued in the form of bulletins of the Laboratory. Our operations during the past two years have been also greatly influenced by legislation concerning the Columbian Exposition, by which it is made our duty to exhibit the methods and the results of the work of the Laboratory. The State Board of Exposition Commissioners looks to this institution, in fact, for a display of the zoölogy of the State, prepared and arranged with special reference to our work.

ORGANIZATION.

The regular Laboratory force, to July, 1891, consisted of the undersigned, serving as Director and State Entomologist; Professor Burrill, of the University, as botanist; C. A. Hart as office entomologist; John Marten as field entomologist; A. M. Westergren as artist; and Mary J. Snyder as secretary and stenographer. During a part of this year H. S. Brode, of the University, served as zoölogical assistant, H. C. Forbes as librarian, and S. Shiga as janitor.

The same staff was continued to July, 1892, with the substitution of Miss Lilly M. Hart as artist, in place of Mr. Westergren. Since July, we have had engaged on regular laboratory work, in addition to the foregoing but with the exception of Professor Burrill, Philip M. Huckle in entomology, succeeded by W. A. Snow. We have further employed on the preparation of the zoölogical exhibit of the Laboratory at the Columbian Exposition, C. F. Adams, taxidermist, and Hugo Kahl as his assistant; H. E. Summers, entomologist; F. M. Woodruff and Ernest Forbes, ornithological collectors; F. M. McElfresh, entomological assistant; and C. T. Wilder, succeeded by J. E. Hallinen, engaged in making a collection of the fishes of the State—all this last group being paid by the World's Fair Commissioners.

The force actually under engagement at any one time has varied from six to sixteen.

INVESTIGATION.

The investigations of the Laboratory during the period covered by this report have followed the same general direction as during the two years preceding, but with closer concentration on entomology than I like—a defect which I hope to avoid hereafter by changes in organization.

Progress in our knowledge of the general zoölogy of the State has been immediately furthered by a considerable amount of work done on waters outside our limits by myself and my assistants, during our vacations, under the auspices and at the expense of the United States Fish Commission. One able to appreciate the fact that the life of no region can be thoroughly studied without a knowledge of that of other regions, adjacent and remote, and that in those departments of natural history where new forms must be described it is indispensable that opportunity should be had for a comparison of collections made over a large extent of country, will understand the advantages to our own studies which this extension of our aquatic work outside the State must bring us in the end. The parties kept in the field ever since last fall on behalf of the Exposition collections, have also added considerable material and information available for the purposes of our natural history survey. I need, however, as I have needed for some years, a zoölogical assistant, whose time should go continuously to the zoölogical survey outside of entomology. In the entomological department of the survey, Exposition work has likewise aided us immensely. The collections and various studies which this work has required in all parts of the State, have given us a mass of facts and material equivalent, I think, to the product of five years of our ordinary operations.

The principal trips made by the entomological assistants for these collections and investigations are thirty-two in number, and cover, for the two years, 298 days' absence in the field at a distance from Champaign. The ornithological field work includes a trip of two months to Louisiana, made by Mr. Adams for the collection of Illinois birds in their winter quarters; three weeks' shooting in southern Illinois by two assistants; five more by one assistant in the northern part of the State, besides six weeks' collecting in Champaign county. In ichthyology, one or two men have been out continuously for three and a half months.

Our outside aquatic operations include a journey to Yellowstone Park and western Montana by Mr. Brode and myself, covering five weeks, in 1891, and trips by myself and two assistants to Geneva, Delavan, and Winnebago lakes, in Wisconsin, occupying four weeks in all. I need not say that our trips of this description were not mere expeditions for the collection of specimens, but that they were attended and followed by field and laboratory studies of the waters, their surroundings, and their contents.

I may add, under this head, brief mention of the experimental work in economic entomology done at my office. The most important subject of precise investigation belonging here is that of the contagious diseases of insects, upon which we have worked almost continuously in the experimental way since the spring of 1891. Artificial cultures of the fungus parasite found most efficient for the propagation of such diseases have been made on a large scale, and supplied to all applicants from this State in sufficient quantities to enable them to start disease among injurious insects on their premises.

We also experimented last year with the fruit bark beetle, the white grubs, and the Hessian fly, with a view to clearing up doubtful points in the life history of each; and with respect to the species last mentioned, we under-

took, at the request of the United States Entomologist, the introduction of one of its foreign parasites into the wheat fields of Illinois.

A very large amount of entomological breeding-cage work has been done by us in the two years just past, but of a kind which it is impossible to summarize. Something of the amount of general work done in entomology may be inferred from the fact that we have added to the pinned collections fully 20,000 specimens, and to the "biological" series, that illustrating the life history and habits of Illinois insects, 2,700 bottles and vials.

PUBLICATIONS.

The regular publications of the Laboratory and Entomologist's office during the past two years have been less numerous than usual; but the matter now in press and far advanced in printing is, on the other hand, unusually important.

My sixth report as State Entomologist, the seventeenth of the entire series, was printed in 1891. It contains 105 pages and seven plates, three of which are colored, with an appendix of 36 pages and one plate. One of the articles of this report was issued separately in advance, as a bulletin of the office. My seventh report is now in course of preparation.

A second edition of the first volume of our report on the ornithology of the State, authorized by the legislature at its last session, has been long delayed, owing to difficulties concerning the supply of paper. These have been met, however, by the State Board of Contracts, and the printing from our stereotyped plates is in progress at the time of writing. This volume stops with the Columbidae, but a continuation and completion of this work on the systematic ornithology of the State has also been printed, and is now nearly ready for distribution as a first part of the second volume of the zoölogical series of the Natural History Survey.

Three articles have been published as bulletins of the Laboratory: one by Professor Weed on a plant louse species, one by Professor Gillette on new gall flies in the Laboratory collections, and one by myself on insect bacteria. We have now in press in this series, and nearly ready for distribution, a full descriptive monograph of the reptiles and amphibians of the State (173 pages and seven plates), by Professor Garman, and a similarly exhaustive account of the Illinois species of one of the families of true bugs (Membracidæ), by Dr. F. W. Goding.

Besides these regular publications we have prepared and printed, in connection with the distribution of collections to be referred to later, two lists, one of duplicate insects in the collection of the Laboratory (nineteen pages), and one a list of economic species for public schools (thirteen pages).

The following is a list of papers by the Laboratory force, published during the two years, the work for which has been done at the Laboratory.

- Forbes, S. A.—Synopsis of Recent Work with Arsenical Insecticides. (Trans. Ill. State Hort. Soc., 1889, p. 310.)
- On a Bacterial Insect Disease. (North American Practitioner, 1891, p. 401; Am. Monthly Micr. Journ., 1891, p. 246.)
- Bacteria Normal to Digestive Organs of Hemiptera. (Bull. Ill. State Lab. Nat. Hist., iv, page 1.)
- On Some Lake Superior Entomostraca. (Rep. U. S. Fish Comm., 1887, p. 701.)
- Preliminary Report upon the Invertebrate Animals inhabiting Lakes Geneva and Mendota, Wisconsin, with an Account of the Fish Epidemic in Lake Mendota in 1884. (Bull. U. S. Fish Comm., viii, p. 473.)
- A Summary History of the Corn-Root Aphis. (Insect Life, iii, p. 233.)
- On the Life History of the White Grubs. (Insect Life iii, p. 239.)
- Report of Progress in Economic Entomology. (Proc. 4th Ann. Convention Ass'n Am. Agr. Colleges and Exper. Stations; in Misc. Bull. No. 3, U. S. Dept. Agr., Office Exper. Stations, p. 29.)
- The Hessian Fly. (Bull. Univ. Agr. Exper. Station, No. 12, p. 377.)

Forbes, S. A.—Continued.

The Fruit Bark Beetle. (Bull. 4, Office State Entomologist Ill.; Bull. Univ. Ill. Agr. Exper. Station, No. 15, p. 469.)

Zoölogy in the Public School: Choice and Arrangement of Material. (Public School Journ., xi, pp. 230, 375, 429.)

The Head of the English Sparrow. (Prepared in accordance with a requirement of the law of the legislature, passed at its last session, offering a bounty for the destruction of sparrows.)

The Chinch Bug in Illinois, 1891-92. (Bull. Univ. Ill. Agr. Exper. Station, No. 19, p. 44.)

An All-around Microscope. (Am. Monthly Micr. Journ., 1892, p. 91.)

The Fruit-Destroying Insects of Southern Illinois. (Trans. Ill. Hort. Soc., 1891, p. 116.)

The Importation of a Hessian Fly Parasite from Europe. (Insect Life, iv, p. 179.)

Seventeenth, Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois. *Contents.*—The Fruit Bark Beetle. Experiments with Arsenical Poisons for the Peach and Plum Curculio. The American Plum Borer. On the Common White Grubs. Additional Notes on the Hessian Fly. A Summary History of the Corn Root Aphis. On a Bacterial Disease of the Larger Corn Root Worm. Notes on the Diseases of the Chinch Bug. *Appendix.*—An Analytical List of the Entomological Writings of Wm. LeBaron, M. D., Second State Entomologist of Illinois.

Marten, John.—Various entomological articles, published as Entomological Editor of the "Prairie Farmer," Chicago, Ill.

Hart, Charles A.—The Life History of Wireworms. (Insect Life, iii, p. 246.)

On the Species of *Ecanthus*. (Entomological News, iii, p. 33.)

Additional papers, prepared but not yet printed, are a presidential address on "The Progress of Economic Entomology during the years 1891 and 1892," delivered by myself at the meeting of the American Association of Economic Entomologists at Rochester, N. Y.; my preliminary report to the United States Fish Commissioner, on the "Aquatic Invertebrate Fauna of Yellowstone Park, Wyoming, and of the Flathead Region of Montana;" and two important papers, now in the hands of my assistants, well advanced towards comple-

tion; the first by Mr. Marten, containing descriptions of new species of Illinois gall gnats, and the other by Mr. Hart—a descriptive list of the aculeate Hymenoptera of the State.

Reference should here be made, for the purpose of completing this summary of our services in the field of economic instruction, to the various addresses made within the State by Mr. Marten and myself.

DISTRIBUTION OF MATERIAL.

In pursuance of the plan mentioned in my last biennial report, 14,000 insects were distributed during the winter of 1890-91 to thirty-nine public schools. These sets were named, labeled, and systematically arranged, and were accompanied by printed pamphlets giving the information necessary to make them available for use in the work of the schools. Notwithstanding this heavy draft on our duplicate material, our entomological collections are already larger than before the distribution was made.

The fact that the insects belonging to the State Laboratory of Natural History are now kept in the University building, and are held at the service of students, under suitable conditions, makes unnecessary any further collections, at present, under the law requiring a cabinet of insects to be prepared by the State Entomologist and deposited at the University.

No collections have been sent during the past two years to the State educational institutions or to the State museum, but according to a resolution passed by the State Board of World's Fair Commissioners last spring, it is held that the collections now being made by the Laboratory for Exposition purposes, will be available at the close of the Exposition for distribution by the Laboratory to these institutions.

S. A. FORBES,
Director.

September 13, 1892.

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May 28 '95.

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

CHAMPAIGN, ILL.

BIENNIAL REPORT

OF THE

DIRECTOR

1893-1894

CHICAGO :
HORNSTEIN BROTHERS, PRINTERS
1894.

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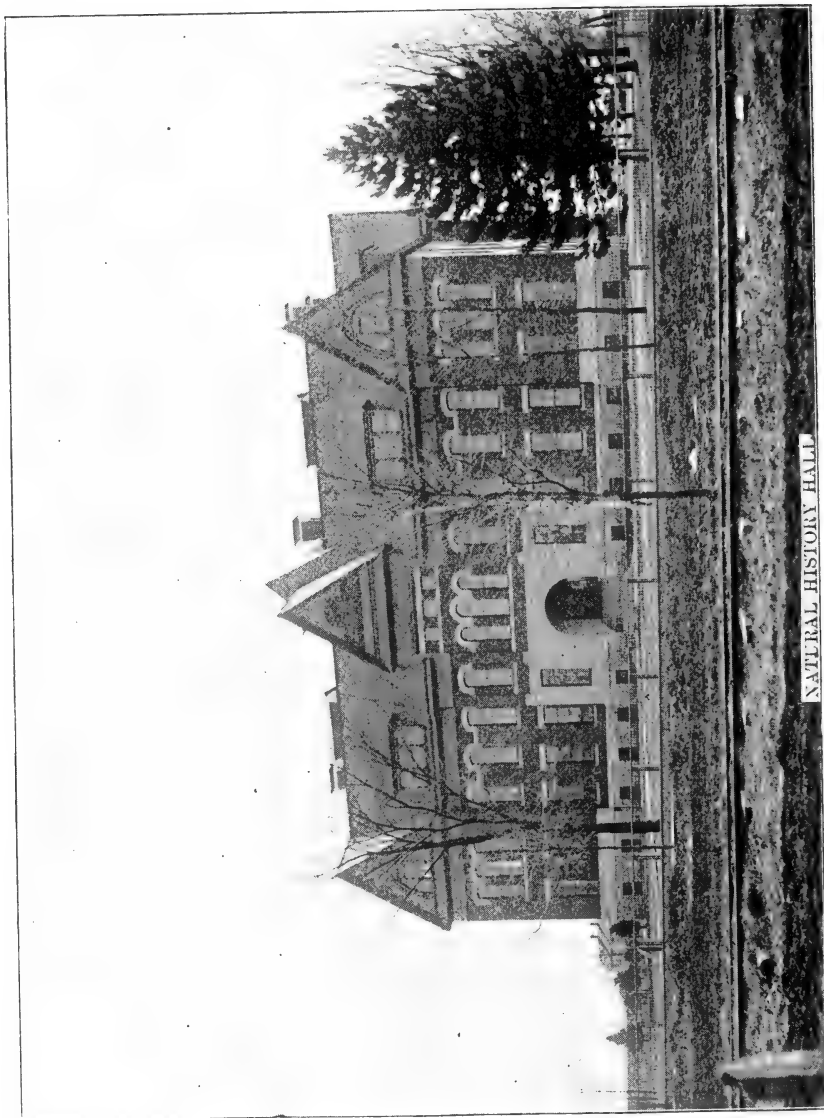
DEPARTMENT OF

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ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

CHAMPAIGN, ILL.

BIENNIAL REPORT

OF THE

DIRECTOR

1893-1894

CHICAGO :
HORNSTEIN BROTHERS, PRINTERS
1894.

State Laboratory of Natural History.

LABORATORY STAFF.

PROFESSOR STEPHEN ALFRED FORBES, Ph. D., Director
of Laboratory and State Entomologist.

JOHN MARTEN, Field Entomologist.*

WILLIS GRANT JOHNSON, A. M., Assistant Entomologist.†

ASSISTANT PROFESSOR HENRY ELIJAH SUMMERS, B. S.,
Assistant Zoölogist.‡

FRANK SMITH, A. M., Assistant Zoölogist.**

CHARLES ARTHUR HART, Curator of Collections.

HENRY CLINTON FORBES, Librarian.

LYDIA MOORE HART, Artist.

MARY JANE SNYDER, Stenographer.

*Resigned August 15, 1894.

†Appointed July 1, 1894.

‡During 1893.

**During 1894.

BIENNIAL REPORT.

TO THE TRUSTEES OF THE UNIVERSITY OF ILLINOIS:

GENTLEMEN: In accordance with your requirement as expressed in your action concerning the status of the State Laboratory of Natural History, taken June 8, 1892, I beg to submit the following report on the work of the Laboratory during the two years just passed.

The points of principal interest in our recent operations are (1) the Columbian Exposition exhibit of the zoölogy of Illinois, made by the Laboratory in 1893 under the auspices of the State Board of World's Fair Commissioners, and the accumulations of material coming into our possession at the close of the Exposition; (2) the establishment, conjointly with the University, in 1894, of a biological station for the continuous investigation of the aquatic life of the Illinois River and its dependent waters, near Havana; and (3) an elaborate experimental work done this year with measures for the destruction of the chinch bug, and especially for the dissemination of the contagious diseases of that insect, undertaken by the Laboratory staff, with the coöperation of the State Agricultural Experiment Station.

COLUMBIAN EXPOSITION EXHIBIT.

Our zoölogical exhibit, occupying 3,000 square feet of floor space in the Illinois State Building at Jackson Park, was so planned as to present the main and most attractive features of the native animal life of the State, and at the same time to illustrate the operations of the State Laboratory of Natural History, and of the State Entomologist's office associated with it. The exhibit was thus limited to specimens of the birds, fishes, and insects of the State.

The relations of the Laboratory to the University of Illinois were shown by the position of this exhibit—immediately beside

A. D. 3973

that of the University College of Science, and opposite the exhibits of the College of Agriculture and of the Agricultural Experiment Station, with only an aisle intervening.

The leading features of our display were a most excellent collection of the birds of the State and of their eggs; a series of entomological collections, scientific, educational and economic; a model economic entomologist's office and insectary; and a nearly complete display of the fishes of Illinois in alcohol.

The entomological collections were shown in connection with the model entomologist's office, which contained five hundred and forty square feet in one room, with an annex twenty feet long by eleven feet wide for an insectary. Into this room were put a select and carefully arranged equipment for first-class work in all departments of technical and economic entomology, sufficient for the use of a chief entomologist and two assistants, including furniture, a section of the Laboratory library, a part of the library catalogue, record books with examples of the records, specimens prepared and arranged in the various ways useful for reference, apparatus for collecting and experiment, microscopes, a drawing equipment, and the like, making of the whole a model establishment which, it was believed, might be profitably studied by any economic entomologist, foreign or American. In the insectary was placed apparatus of various kinds for the breeding and rearing of insects of injurious habit, and for the cultivation of the plants subject to insect injuries upon which experimental methods might be demonstrated.

The special exhibits made in this entomological department included a collection of sixteen hundred species of common Illinois insects, so selected as to present a correct general idea of the insect life of the State; separate collections of insects, in their various stages, injurious to corn, to wheat, to the apple, and to the strawberry in Illinois, together with characteristic examples of their injuries; a special exhibit of the food of one robin for one year, based upon studies made at the Laboratory and published in our Laboratory bulletins; a set of insects ascertained to have been eaten by birds; a similar series eaten by fishes; a set of butterflies arranged with a view to illustrating the geographical distribution of insect species in Illinois; and a set of Illinois insects illustrating the work of the Laboratory in supplying entomological material to the high schools of the State.

The ornithological exhibit was made in four series: (1) A collection of the game birds of the State, mounted as dead game; (2) a series of biological groups mounted in various naturalistic attitudes, with natural accessories indicating habits, haunts, and the like; (3) a general collection of all the birds of the State, grouped according to their distribution within the State at different seasons of the year; and (4) a set of the eggs of birds breeding in Illinois.

Our ichthyology was illustrated by one hundred and fifteen species of fish from various parts of the State, collected by the Laboratory force and exhibited in alcohol.

To this general account the following detailed statement may be added.

ORNITHOLOGICAL EXHIBIT.

Winter residents of Southern Illinois.....	108	specimens.
“ “ of Northern Illinois.....	44	“
“ “ throughout Illinois.....	141	“
Summer residents of Southern Illinois.....	38	“
“ “ of Northern Illinois.....	59	“
“ “ throughout Illinois.....	207	“
Migrants passing through Illinois.....	77	“
Stragglers in Illinois.....	24	“
Common game birds of Illinois mounted as dead game.....	53	“
A group of Wild Turkeys mounted with natural- istic accessories.....	6	“
A group of Prairie Chickens mounted with natu- ralistic accessories.....	4	“
A group of Crossbills mounted with naturalistic accessories.....	8	“
A group of Yellow-bellied Sapsuckers with nest and eggs.....	4	“
A pair of Little Green Herons with nest and eggs	2	“
<hr/>		
Total number of birds exhibited.....	775	“

One hundred and twenty-five clutches of birds' eggs, representing as many species of birds nesting in Illinois, were also shown, the total number of eggs in these clutches being five hundred and twenty-five.

ENTOMOLOGICAL EXHIBIT.

	Pinned specimens.	Vials.	Draw- ings.
Illinois Insects injurious to the Apple.....	240	106	57
“ “ “ “ Corn.....	150	85	22
“ “ “ “ Wheat.....	53	43	9
“ “ “ “ the Strawberry.	52	20	13
Insects in the food of Birds.....	195	24	
“ “ “ “ “ Fishes.....	91	9	
Geographical distribution of Illinois Butter- flies.....	184		
Illinois Insects as furnished to High Schools of Illinois.....	459		
Common Insects of Illinois:			
Dermaptera	4		
Orthoptera	215		
Platyptera.....	12		
Odonata.....	73		
Plectoptera.....	8		
Hemiptera.....	566		
Neuroptera	20		
Mecoptera.	4		
Trichoptera.....	3		
Coleoptera.....	2662		
Diptera.....	541		
Lepidoptera.....	1058		
Hymenoptera	1016		
	----	----	----
Total.....	7606	287	101

In addition to the above there were exhibited about 3,000 specimens of Lepidoptera and Coleoptera, twenty boxes each, from the standard collection of the State Laboratory, and twenty-four racks of vials (about 500) of alcholic specimens.

The special exhibit of the food of one robin for one year consisted of 5,481 pinned specimens of insects, eighty tubes, each fifteen inches in length, containing alcholic specimens, and thirty-eight shorter tubes and vials of alcholic specimens, besides vials and tubes containing fruit and seeds.

The total number of separate objects shown in these collections was 18,550.

The furniture of the entomologist's office comprised two office desks, four plain work tables, three tables with specimen cases, a table for reference books and record books, two small cases for specimens, a large bookcase, two reagent-cases, a type-writing machine and desk, a letter-press and stand, a small printing-press and case of type, a sink, and some chairs.

In the bookcase was placed a section of the library of the State Laboratory of Natural History, the books selected being mainly entomological, and including serial publications, periodicals, monographs, reference books, pamphlets, etc., to the number of about five hundred volumes. A complete set of the publications of the Laboratory and of the State entomological reports was also displayed on one of the office tables.

Under the head of working apparatus, there were shown in this room one compound microscope and accessories, two dissecting microscopes and accessories, two large microtomes, a complete outfit for collecting insects, sets of bottles, vials, and reagents for preserving insects, an apparatus for inflating larvae, and that used in mounting and preserving insects.

In the insectary, adjoining the office room, were sixty large and small breeding cages with glass fronts and gauze sides; forty glass jars of various sizes and shapes, to be used as breeding cages; and two gauze-covered cages suitable for outdoor use. These were arranged on shelves and on a table covered with sand. There were also in this room a work table with an Arnold steam sterilizer, large culture jars and funnels, and other apparatus used in the culture of fungi causing insect disease.

The zoölogical display was made in accordance with detailed plans prepared by the Director of the State Laboratory, the execution of which was confided to Mr. Charles F. Adams* for the birds, and to Prof. H. E. Summers for the insects.

The material for the ornithological exhibit was chiefly obtained by special collections made for this purpose during the

* The sudden and wholly unexpected death of Mr. Adams at Chicago while engaged in the installation of this exhibit, to whose preparation he had devoted nearly two years of intense and unremitting labor, brought to a mournful and untimely end the promising career of an excellent naturalist and a most lovable man. Admirably equipped by his university education, by his very unusual artistic skill as a preparator of zoölogical material, and by his experiences of scientific travel in various parts of the world, he seemed merely at the beginning of a life of eminent usefulness to science and to the State.

winter of 1891 and the spring and summer of 1892 by parties sent out from the Laboratory, and mounted by Mr. Adams himself. As it was quite impossible to make a complete collection of the birds of the State within so short a time, the deficiencies remaining were supplied by selections made from the museums of the University of Illinois, at Champaign, and of the State Board of Agriculture at Springfield, and by purchase of skins from taxidermists.

The entomological exhibit was likewise provided in part from special collections made by Laboratory employees and by assistants especially engaged for the purpose, and in still greater part from the cabinets of the State Laboratory and of the University of Illinois.

The beautiful colored drawings, one hundred and one in number, distributed through the entomological exhibit to illustrate species too small to be well seen by the naked eye, were made at the State Laboratory for the purpose by Miss Lydia M. Hart, the special artist of the establishment.

The ichthyological collections were all made during the season of 1893 by assistants sent from the Laboratory, Mr. J. E. Hallinen, a student of the University, doing the greater part of the field and laboratory work.

It may be proper to place on record here some statement of the manner in which this exhibit was received by those best qualified to appreciate it. In the *Auk** for October, 1893, Mr. Frank M. Chapman, of the American Museum of Natural History, at Central Park, New York, writes in an article on "Ornithology at the World's Fair," that "Illinois was easily the leader in the department of local collections representing the bird life of a state or province. Its collection," he says, "placed in the State Building, is well mounted, and the method of arrangement is one which might well be followed in the display of similar collections." Elsewhere he says that it is by far the best state collection that he has ever seen. Mr. Robert Ridgway, Curator of Ornithology to the United States National Museum, writes of it also as "incomparably superior to any other state exhibit at the Fair, and a very close competitor with the Government exhibit." He says, "I do not see how, making due allowance for limited time and means, it could have been improved."

*A quarterly journal, the organ of the American Ornithologists' Union.

Equally flattering comments were made upon the entomological features of the exhibit by economic entomologists, both American and foreign, the collection of apple insects especially, and that exhibiting the food of a single robin for one year, attracting wide attention.

The entire mass of this material, excepting only a few birds borrowed from the museum of the University and seventy-one specimens from that of the State Department of Agriculture, was, at the close of the Exposition, transferred by the State World's Fair Commissioners to the Illinois State Laboratory of Natural History and removed to Champaign. The ornithological collection thus acquired I have placed in the museum of the University so far as the cases there will contain them, and the remaining material is now in the collection rooms of the State Laboratory, in the basement of Natural History Hall.

THE EXPOSITION AQUARIUM.

This is the proper place to mention also a very important gift made to the Laboratory by the United States Commissioner of Fish and Fisheries, Hon. Marshall McDonald, at the close of the Exposition. As the attendant circumstances were imperfectly understood at the time by the public at large, it seems desirable to place on record here a correct account of this transaction.

Under your authorization, as recorded in your Proceedings for November 16, 1892, I accepted an appointment as Director of the Aquarium Exhibit of the Commission at the Columbian Exposition, taking charge January 1, 1893, and continuing to serve in that capacity to the close of the Exposition, October 31. At this latter date the living inmates of the Aquarium comprised representatives of fifty-two species of marine and sixty-two species of fresh water animals, about 2,500 specimens in all.

It was the earnest wish and hope of the Commissioner and myself that the maintenance of this live exhibit at the Exposition—of which it was throughout one of the most attractive features—might result in the establishment at Chicago of a permanent aquarium and biological station, and to this end I was authorized in October to offer the contents of the tanks in the Aquarium Building, with some unimportant exceptions, first to

the Trustees of the proposed Columbian Museum, and, second, to the South Park Commissioners of Chicago, under such conditions only as would secure the maintenance of the establishment and its development as a popular aquarium and a station for scientific research. This offer I made to the trustees of the museum October 12, and more fully October 23, in the following letter addressed to the Secretary of the Board.

* * * "I beg to add to the representations of my letter of October 12 this formal tender, to the trustees, of the present living contents of the aquarium tanks (together with the supply of sea water in circulation), with the exception of the sea anemones, the viviparous perch, and the specimens of the various species of trout, which are reserved by the Commissioner for use elsewhere. This offer is subject to the following conditions, intended only to enable me to assure the Commissioner that the purposes he has had in view in establishing and maintaining the aquarium exhibit will be substantially secured.

"It is of course to be presumed and understood that if these collections are accepted, it will be with the wish and intention of maintaining them as a live exhibit for the public benefit on at least their present scale of number and variety. Such specimens as die in the aquarium during the next six months are to be placed in alcohol and turned over to the Illinois State Laboratory of Natural History for distribution to the public high schools and State educational institutions, according to the law defining the duties of the Laboratory.

"We beg also that the trustees will formally express the intention, which we are satisfied that they entertain, of using their best endeavors for the development of the aquarium as a scientific institution—a biological station, in fact—with the expectation of affording to scientific men, in due season and according to the apparent demand therefor, facilities for the study and experimental investigation of the plant and animal life of the fresh waters of this country. To this end we believe it indispensable that the aquarium should be at all times under the general supervision of an experienced scientific biologist, capable of rightly shaping its general policy, and competent by training and ability to utilize for the advancement of science the abundant opportunities for observation and experiment which such an establishment must afford.

“The very short time now available for the organization of an aquarium staff qualified and prepared to take charge of this highly perishable material, crowded as this time must be with an overwhelming multitude of other equally urgent affairs, leads us further to request that we may be assured of the appointment, for a period of six months, of an expert superintendent and experienced assistants, who shall be acceptable to the Commissioner, or his representative, as in every way competent and sufficient for the care of this material under the circumstances existing and soon to ensue. The destructive consequences to our delicate and perishable collections which must follow upon even a temporary mistake in this matter, and the unfortunate complications likely to arise if a wrong beginning were made, lead us to ask that our judgment—greatly enlightened as it has been by the season’s experience with the present aquarium plant—may thus be allowed due weight in the selection of the temporary aquarium staff upon whom the care of the material for the winter will fall. As this is perhaps the most difficult and important, and at the same time the most urgent, feature of the proposed arrangement, I have anticipated the action of the trustees so far as to get the consent of the Commissioner to the continuance—for some months if desired—of one of the present aquarium superintendents, a regular employee of the Fish Commission, to whom the Commissioner is willing to give leave of absence for a time, to enable him to help over the emergency. I have also ascertained that all the present aquarium assistants, who are now a body of picked and trained men, thoroughly acquainted with the situation and their duties, would be willing to continue, at least for a time, in their present employment. The existing organization can thus be carried over, without a break, in a way to secure the safety of our material for the winter, and to give the trustees ample time to mature a permanent organization and select a satisfactory staff.

“So far as the general zoölogical supervision of the aquarium is concerned, I beg to say that it will be a pleasure to me to serve the trustees temporarily in this matter, with the understanding that I shall be relieved as soon as a satisfactory selection of a permanent director can be made.

“The foregoing statement contains all the conditions precedent to a transfer. It will be seen that they are intended merely

to find a basis of agreement between Commissioner McDonald and the Trustees of the Columbian Museum as to the general purposes and policy of the aquarium, and to secure the safety of the collections during the period of readjustment and reorganization.

"I should add as an item of information which may be of interest to you, that it is now agreed that in case the arrangement here proposed is not made, the collections shall be placed in charge of the Illinois State Laboratory of Natural History (of which I am Director) for distribution to the public high schools and educational institutions of the State of Illinois. I very much prefer, however, such disposition of them as may result in a permanent, living, active scientific institution of the first class, so related and supported as to give us a fair assurance of its development in accordance with the importance of its field and the greatness of the city which it will represent.

"I am further authorized by Commissioner McDonald to say that if such an institution be provided for in Chicago, he will be glad to undertake to establish in connection with it a first-class fishcultural station of the United States Fish Commission, on condition that grounds can be found for such an institution. If this idea was carried out, we should have, practically in one institution, a popular aquarium of the first class, a biological station maintained in the interests of science, and a Fish Commission station devoted to the practical application of aquatic zoölogy. Such an association of kindred undertakings would greatly reduce the cost of maintaining each, as many of the facilities and much of the apparatus could be adapted to all three as readily as to one alone."

The Museum Trustees were eventually obliged to decline the proposed gift, owing to a lack of funds secured and available for either immediate or permanent maintenance, and owing also to the incompleteness of the Museum plans and organization at that early date, and I therefore made an identical proposition to the South Park Commissioners. In the meantime, in order to facilitate the final disposition of the aquarium material, and to make sure that it would be properly utilized in any event, an arrangement was made for its transfer, November 1, to the State Laboratory of Natural History, and I was so notified October 25 by the following telegram from Commissioner McDonald:

"I have determined, with one exception, which I have indicated to you, to turn over all the aquarium material to the State Laboratory of Natural History for such disposition as the Director in his discretion may find best."

This tender was formally accepted by me October 30, in the following letter to the representative of the Commission at Chicago:

"In reply to your favor of October 26, notifying me that you are prepared, in accordance with the instructions of the Commissioner, to turn over to the State Laboratory of Natural History the specimens now in the Aquarium, with certain exceptions reserved by the Commissioner, I beg to say that I shall accept with pleasure, on behalf of the Laboratory, all of this material which I find suitable for use or distribution by us.

"I need not say that I recognize most gratefully the very great obligation conferred by the Commissioner upon the State Laboratory of Natural History, and upon the scientific and educational institutions dependent upon it in part for their supply of scientific material. Such specimens as I take possession of will be utilized to the very best of our opportunity for purposes of scientific study and instruction."

Being notified October 31, by one of the commissioners of the South Park, that that commission would probably accept the aquarium on the conditions named, and would, at any rate, provide temporarily for its maintenance until formal action could be taken by them, I did not disturb it until November 7, at which time the Park commissioners decided not to undertake to provide for its permanent support and development. I consequently then took charge of its contents for the State Laboratory; distributed such portion of them to the colleges and high schools of Chicago as they could utilize and care for; shipped the live marine material to Champaign for an experiment in aquarium maintenance; and placed the remainder in alcohol for subsequent distribution to scientific institutions and public high schools.

A most careful and persistent effort made at the University to maintain these marine animals in tanks of sea water by the aid of a mechanical aërating apparatus such as we used in Chicago, gradually failed through the unavoidable fouling of the water due apparently to the lack of marine vegetation, which the exigencies of the time had made it impossible for me to

provide in advance. The specimens dying were, however, preserved and added to the mass of material held for the supply of public schools and other educational institutions of the State.

My experiment here, and my much more valuable experience at the Exposition Aquarium in the thoroughly successful maintenance of marine animals under artificial conditions, have given me positive assurance that it would be quite practicable, within the limits of a reasonable expenditure, to maintain at this distance from the sea a salt water aquarium continuously, year after year, in which the more hardy and interesting forms of marine life could be exhibited for the benefit of a general public, and likewise for that of university students. I desire to commend this matter very earnestly to your attention, especially as no university in America not in the immediate vicinity of the sea is at present doing anything whatever in this direction. The maintenance of a fresh water aquarium, although more difficult than that of a marine exhibit, would be in many respects more convenient and in every way equally useful. The two sorts of collections could, of course, be readily combined in the same establishment. This enlargement of our facilities would be particularly helpful as an apparatus for experimental investigation in connection with the Biological Station on the Illinois River, now maintained jointly by the State Laboratory and the University of Illinois. I suggest it to you for consideration in connection with plans for a university museum building, with which it might best be associated both in management and construction.

THE BIOLOGICAL STATION.

I have next to report the establishment last spring, in leased quarters on the Illinois River, at Havana, of an aquatic Biological Station, jointly maintained throughout the season by the University of Illinois and the State Laboratory of Natural History.

This Station was opened April 1, under authority of the Trustees of the University given in your action on a communication submitted by me to your Committee on Instruction March 2, 1894, and printed in part in the Proceedings of the Board for March 13 (p. 114). As the appropriation made by you to this end from the University funds was not immediately avail-

able, the Station work was carried by the State Laboratory until July 1, and the resources of the Laboratory will also be further drawn upon, as may be necessary, for its support until the legislature may have had time to act upon our request for the means of future maintenance.

As this establishment is unique in this country, and is in some important respects the only one of its kind in the world, I shall feel obliged to enter into some detail concerning its purposes, organization, and operations. Since it is now, and, in my judgment, should continue to be, supported jointly by the University and the Laboratory, I can best report upon it here from both these points of view.

The Station depends for its establishment, perpetuation, and development on the acceptance of the following general ideas: That it is a part of the office of a university, properly so-called, to promote the progress of pure science; that an institution whose scientific work is closely limited to the economic field may be an industrial school, but cannot be a university; but that a state institution both educational and scientific in its character should stand in the closest possible relation to the general public welfare, and hence should work out in every direction the application of the results of its investigations to industrial and educational affairs; and that a state institution of this character should help especially to make the people of the state acquainted with the state itself.

The general objects of our Station are to provide additional facilities and resources for the natural history survey of the State, now being carried on, under legislative authorization, by the State Laboratory of Natural History; to contribute largely to a thoroughgoing scientific knowledge of the whole system of life existing in the waters of this State, with a view to economic as well as educational applications, and especially with reference to the improvement of fish culture and to the prevention of a progressive pollution of our streams and lakes; to occupy a rich and promising field of original biological investigation hitherto largely overlooked or neglected not only in America but throughout the world; and to increase the resources of the zoölogical and botanical departments of the University by providing means and facilities for special lines of both graduate and undergraduate work and study for those taking major courses in these departments.

The Station differs from most of the small number of similar stations thus far established in this country in the fact that its main object is investigation instead of instruction, the latter being a secondary, and at present an incidental, object only. It has for its field the entire system of life in the Illinois River and connected lakes and other adjacent waters, and it is my intention to extend the work as rapidly as possible to the Mississippi River system, thus making a beginning on a comprehensive and very thoroughgoing work in the general field of the aquatic life of the Mississippi Valley, in all its relations, scientific and economic.

The special subject which I have fixed upon as the point of direction towards which all our studies shall tend, is the effect on the aquatic plant and animal life of a region produced by the periodical overflow and gradual recession of the waters of great rivers, phenomena of which the Illinois and Mississippi rivers afford excellent and strongly marked examples. The field is entirely fresh, no such investigation having been before undertaken anywhere in the world. It is highly interesting and important, including in its scope very nearly every topic concerning the life of our waters which in any way interests the biologist or the practical man, and it is one for whose investigation we are perhaps better prepared by experience, equipment, purposes, and associations than any other institution or group of naturalists in the country.

As an incidental, but by no means unimportant, result of our work we shall accumulate the material for a comparison of the chemical and biological conditions of the waters of the Illinois River at the present time and after the opening of the Chicago drainage canal.

The practical importance of our undertaking as affording the only sound basis for a scientific fish culture is fully recognized by the highest American authority in this field. In a recent letter on this subject, Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, says:

"I have carefully gone over the plans of the biological station proposed by you, and am particularly struck with the comprehensiveness of the plan of work to be undertaken. The knowledge to be obtained by such investigation as you contemplate is absolutely necessary as a foundation upon which to build an

intelligent, rational administration of our fishery interests. A knowledge of life in its relation to environment is an important subject which biological investigators have not heretofore sufficiently dealt with, but which, it seems to me, is necessary in order to give practical value to special studies of the different species. After all, it is the relations and interdependence of life in the aggregate, and of the conditions influencing it adversely or otherwise, that mainly concern those who are seeking to apply scientific methods of investigation to economic problems.

"I need not tell you that you may count on the Commission for any coöperation and aid that we may be able to give you in this direction, which, looked at from a purely economic standpoint, I consider of the utmost importance."

The Station will also serve as a center of interest and activity for University students engaged on zoölogical and botanical subjects, and will in this way supply a most serious deficiency in our equipment, the disadvantages of which I have long deplored. Not many years ago biological instruction in American colleges was mostly derived from books; of late it has been largely obtained in laboratories instead; but several years' experience of the output of the zoölogical college laboratory has convinced me that the mere book-worm is hardly narrower and more mechanical than the mere laboratory grub. Both have suffered, and almost equally, from a lack of opportunity to study nature alive. One knows about as much as the other of the real aspect of living nature, and of the ways in which living things limit and determine each others' activities and characters, or in which all are determined by the inorganic environment. I have been particularly struck with the insufficient preparation of the ordinary graduate from laboratory courses in zoölogy for the work of a special instructor in the public schools. He cannot be an intelligent guide and teacher in the field, and he commonly has no command of apparatus and methods of experiment calculated to make his pupils acquainted with the system of the living world.

The immediate and pressing problem of the biological instructor is to provide an equipment and to work out methods by means of which his students may be brought into helpful contact with this world of life while it still lives, and by which they may

be enabled to investigate experimentally the problems of mutual influence and relationship which come under the general head of what is now known as biological œcology. With the new Station at Havana put on a firm foundation and liberally maintained, the University of Illinois will be better equipped in this particular than any other institution in America.

The utility of the Station to the University Summer School has already been mentioned. Possibly still more important is the opportunity which it will offer, when permanently established and fairly well developed, to the independent student and investigator, zoölogical or botanical, who may desire to pursue his studies in the field covered by our operations. It is a part of the plan of organization and equipment of our Illinois River Station to receive and assist in every practicable way advanced students and investigators of this description, from whatever place they may come.

Havana was selected by me as the site of the Station because of several unique advantages offered by that locality. Streams and lakes illustrating practically all the typical Illinois River situations are to be found there, convenient of access from a central point and from each other. An extensive sandy bluff, commonly well shaded and oozing spring water at its foot, borders the river bottom on the east, and introduces several unusual features of interest to the œcologist, besides affording a clean and hard shore to work from, dry, shady, and well-drained camping ground, and an abundance of very pure cold water at all times of the year. No other situation at all suited to our purpose could have been selected which was less likely to endanger the health of our field parties, necessarily exposed to malarial infection as they are in midsummer and early fall by the nature and immediate surroundings of their work. The Havana Division of the Illinois Central Railway affords ready means of communication between the Station and the University by trains running without change of cars, and thus makes possible the convenient transportation of live material to the University for study and experimental use, and also gives the students of the summer school a chance to avail themselves of the Station equipment for experience in the field. The absence of any extraordinary source of pollution to the river water nearer than Pekin, thirty miles above, and the neighborhood of the field

operations of the United States Fish Commission at Meredosia, fifty miles below, were likewise points in favor of this location. The summer's experience there has satisfied me that no mistake was made in this respect, but that, on the contrary, the vast abundance and great variety of plant and animal life in the river at that point, and especially in the bottom-land lakes connected with the stream in all stages of water and completely submerged by it in times of overflow, make this locality one of the very best possible for my purposes.

The work was provided for this year in three well-placed rooms in the town itself and in a "cabin boat" on the Illinois River, both furnished from the laboratories and libraries of the University and the State Laboratory of Natural History with everything necessary to first-class work in the collection, preservation, preparation, and systematic study of our material, together with some special pieces of apparatus and other appliances manufactured to our order for this work.

The office and laboratory rooms were supplied with running water and electric light, and liberally provided with the usual equipment of a biological laboratory, consisting of compound and dissecting microscopes (Reichert and Zeiss), microtomes, biological reagents to the number of one hundred bottles, water and paraffine baths, laboratory glassware, tanks for alcohol, a coal stove, a kerosene stove, laboratory tables for five assistants, and a working library of about one hundred and twenty volumes.

The cabin boat was used as a field headquarters, and stationed on Quiver Lake, two and a half miles above the town. It carried the seines, sounding lines, aerial and aquatic thermometers, dredges, surface nets, Birge nets, insect nets, plankton apparatus, and other collecting equipment, together with microscopes (Zeiss and Bausch & Lomb), reagents, a small working library, a large number of special breeding cages for rearing aquatic insects, and a few small aquaria. This boat was provided with sleeping accommodations for four men, and with a well-furnished kitchen.

I have myself exercised a general supervision over the Station work, planning and following its operations as closely as my other responsibilities would permit. Mr. Frank Smith, University Instructor in Zoölogy and Zoölogical Assistant of the State Laboratory, has been in immediate charge of the Station

since April 7. He has been responsible for the execution of the details of the general plan, and for the technical work on aquatic worms. Mr. C. A. Hart, Curator of the collections of the State Laboratory, has done the entomological work of the Station; Mr. Adolph Hempel has worked on protozoans and rotifers; Mrs. Dora Smith has served as our microscopic technologist and has had charge of the rooms down town; and Mr. Newberry, of Havana, has kept the cabin boat with its equipment and done duty as a general assistant. I also had the services of Mr. Ernest Forbes as general collector for about six weeks of the vacation period. Extensive collections and studies illustrating the aquatic botany of the Station have been made periodically at Havana by Professor Burrill, Mr. Clinton, Mr. Yeakel, and Miss Ayers, of the University botanical department. Chemical analyses of the waters from our principal collecting stations have been made at intervals at the chemical laboratory of the University by Professor Palmer, and steps have been taken to secure a good map of the locality. Miss Lydia M. Hart, artist of the State Laboratory, has been at Havana for natural history drawing, and Assistant Professor Summers, of the University department of physiology, spent a part of his vacation making a large series of photographs of the Station and its surroundings for use in illustrating its reports.

The greater part of our field work was done on seven regular stations, visited periodically throughout the year; two on the Illinois River, three on Quiver Lake, and one each on Phelps and Thompson's lakes. The river, about five hundred feet wide at low-water mark, and at the highest water not less than four or five miles across, flows rather sluggishly* over a muddy bed, with banks usually of mud or clay, peculiar, however, in the vicinity of Havana and for several miles above and below that point, in the fact that the eastern and western shores are strongly contrasted in character. The former, as already said, is a bank of sand from twenty to sixty feet in height, with but little mixture of soil, the western border of a sandy plateau which stretches back from the river from twelve to fifteen miles. The face and summit of this slope and a varying extent of country beyond are commonly covered with upland forest trees,

*According to our observations, made when the river stood nearly at low-water mark, the current was less than a mile an hour.

largely oak and hickory. At high water mark this bluff forms the immediate bank of the river itself, but as the water recedes a sloping flat is uncovered, sometimes buried to a little depth in sand, but with clay beneath. This flat widens, here and there, into a boggy or somewhat swampy, belt or patch, thickly overgrown with underbrush and coarse flowering plants. The river runs, in the Havana district, much nearer this bank than the opposite one, so that few of the bottom-land lakes lie between it and the sandy bluff. Where this sand rests on the clay, multitudes of springs ooze forth, forming trickling rivulets, which frequently unite before they reach the river in streams a few feet across. This water is of surface origin, being practically the leachings of the sand bed mentioned. It is remarkably pure, cool, and abundant, entirely free from organic matter, and scarcely at all liable to malarial contamination.

The opposite bank of the river is ordinarily a flat slope of black woodland soil, making, when moist, a treacherous mud, and springing up, when laid bare, with a dense growth of weeds and grass. This bank is subject to overflow commonly twice a year, in late winter or early spring and again in June. During these periods of high water all the bottom-land lakes are of course submerged, becoming distinguished again from the river itself only as the waters recede—perhaps after an interval of several weeks. Most of these lakes are either abandoned portions of old beds of the river more or less completely cut off from the present channel by silting up at either end, or they are similar portions of old beds of tributary streams.

Quiver Lake, in which the headquarters boat was placed, is such a portion of the river bed. It varies in length (when the water is low enough to define it clearly) from one and a half to two and a half miles, and has a usual width of about five hundred feet at low water mark. It lies nearly parallel with the main river, into which it opens, even in the lowest stage of water, at its lower or southern end, by about half its greatest width. At its upper end it receives Quiver Creek, a stream some twenty to thirty feet across, which comes down for several miles across the sandy plateau, receiving some distance above its mouth the drainage of a region formerly filled with swamps. This lake lies at the foot of the sandy bluff, and is separated from the river on the west by a narrow tongue of low black land, either

bare or covered with trees according to its height above the usual water level.

Thompson's Lake lies wholly within the bottom-lands of the main river, and its banks are consequently everywhere low and flat. It is five miles in length by about half a mile in width at an average midsummer stage. When the water is moderately high it can be entered by skiffs from either end, but as the river falls the lake is shut off below, and connects with the stream only by a somewhat tortuous narrow chanel about two miles in length at its northern end. Neither this nor Quiver Lake ever goes dry, the water in the deepest places being not less than three and a half or four feet during the dryest seasons. Phelps Lake, on the other hand, is a pond about half a mile long by a fourth as wide, having neither inlet nor outlet after the overflow has receded, rarely drying up entirely, but not infrequently being reduced to a few shallow pools. It is completely surrounded by a bottom-land forest, and its bed is a mere shallow depression in the mud.

Beside our regular station work, occasional collections were made from various other waters, including Spoon River, Matanzas Lake,—three and a half miles below Havana, on the eastern side of the river,—Clear Lake, Dogfish Lake, Mud Lake, Liverpool Lake, and Quiver Creek.

At each of the above regular stations thoroughgoing collections and careful observations were made at intervals of from one to three weeks, the time varying according to the nature of the station and the teachings of our experience. The mid-stream and mid-lake collections were of two kinds, qualitative and quantitative; the former made at surface and bottom with towing net and dredge, and the latter with a plankton net of the finest bolting cloth (Number 20) hauled from top to bottom at a regular and uniform rate and over identical distances. As the waters in which we worked were much too shallow for profitable vertical hauls—often not more than five or six feet in depth—we tightly stretched a line one hundred feet long obliquely from bottom to surface, and drew the quantitative net along this line, to which it was suspended in a horizontal position by a carriage running along the line on wheels. The contents of the dredge were assorted by the aid of a set of bag sieves of netting and of finer cloth, fitted closely together as one

apparatus by pushing the ring of one net inside that of another, the longest and finest bag being, of course, at the bottom, and the shortest and coarsest at the top, of the set. In the long-shore work we used hand nets of various sorts, the cone dredge of Professor Birge (commonly called the "Birge net" by us), sieves, forceps, and fingers, and occasionally a small minnow seine.

Everything collected was bottled and labeled after such methodical preparation as the case required, with the exception of the common and constant sorts, like the more abundant mollusks and insect larvæ. Concerning these, full notes of abundance, etc., were kept for each station at each visit.

Besides these regular collecting operations, the water temperatures were taken daily, a great variety of notes were made on relative numbers, habitat, habits, life histories, food, and behavior of aquatic and subaquatic animals of every description; special collections of fishes and other forms were accumulated for a study of the food of the species under varying conditions; aquarium and breeding-cage operations were carried on, especially with aquatic insects and insect larvæ, for a study of life histories and the determination of immature stages hitherto undescribed; and critical and final microscopic studies of perishable forms (chiefly protozoans and rotifers) were carried forward.

The force engaged, worked from the beginning of April to October 1, under unusually difficult circumstances, with perfect fidelity and great intelligence, and with tireless energy and enthusiasm. At the latter date the cabin boat was brought in, and all the Station party returned to Champaign except Mr. Hart, who remained two weeks longer. Most of the equipment remains at Havana in the laboratory rooms, and regular trips will be made to the Station during the fall and winter, at intervals of about three weeks, with parties large enough to work every station thoroughly by all the methods above described. It is our intention to ship a large part of these winter collections alive to the University for study on our return from these brief trips.

The results of this first season's work are, of course, but just beginning to appear. Indeed, the problems to be solved in such situations have scarcely more than dimly shown themselves as yet, but the promise is nevertheless already very interesting.

Notable contrasts in kind and number appear between animals of the springy shore of river or lake, and those of the muddy bottom, only a few rods away on the other side; between river and lake; between Quiver and Thompson's lakes; between each of these and Matanzas Lake; and between all the other lakes and the temporary pond distinguished locally as Phelps Lake,—contrasts sometimes easily comprehensible, as in the first instance given, where the cool spring water flowing in abundantly is evidently favorable to the gammarids and aselli swarming there; and sometimes peculiarly puzzling, like that between Quiver Lake on the one hand, whose waters were choked in midsummer with a dense growth of aquatic vegetation but contained fewer of the smaller animal forms (Entomostraca, and the like) than the open current of the river itself, and Thompson's Lake, on the other hand, where the water was relatively clear of aquatic plants but abounded in rotifers and Entomostraca. Still more curious was the contrast between the similarly situated and very similar lakes, Quiver and Matanzas, the waters of one loaded and clogged with plants and swarming with small mollusks and insect larvæ, and those of the other with scarcely a trace of even microscopic vegetation, and with a correspondingly insignificant quantity of animal life.

The course of events in a body of water like Phelps Lake, with its terrific seasonal vicissitudes, ranging from complete overflow and loss of identity to absolute drying away in now and then an exceptional year, is extremely interesting to the œcologist. The extraordinary instability of the system, one predominant and excessively abundant form quickly following another almost to the suppression of its predecessor, and all finally overwhelmed in a common doom, gives to the student an impression of an unhealthy organism, caught in the trap of an unfavorable environment, and hurrying through the stages of a fatal disease.

One of the surprises of the season was the abundance of minute life in the main stream, which, as already intimated, sometimes contained a greater abundance of animal forms than most of the lakes connected with it; and another was the relatively small difference between the animals frequenting widely unlike situations in the same body of water. This is not the place, however, for a summary of our discoveries, and I must content myself with the statement that the freshness and fruit-

fulness of the field was well illustrated by the large number of new forms found, especially among rotifers, worms, and insect larvæ.

The collections of the season, preserved for detailed study, are included under nine hundred and fifty-eight collection numbers, representing as many different lots of specimens. During the relatively quiet winter interval the Station force will be more or less continuously engaged upon determination work and other laboratory studies, and the preparation of reports. Mr. Smith is studying now the oligochaete worms; Mr. Hempel continues his work on the rotifers and Protozoa; Mr. Hart is determining and describing insect larvæ and other aquatic insect forms, and I have made myself responsible for the Crustacea of our collections (with the assistance of Mr. C. F. Hottes, a fellow in the University), and for a general discussion of methods and results. The papers and reports embodying these studies will be printed in the Bulletin of the Illinois State Laboratory of Natural History, with ample illustrations, now being made by Miss Lydia M. Hart. So far as possible, each general taxonomic paper will be preceded by a thoroughly practical synopsis of genera and species, illustrated by figures of typical forms, and intended to open up to the student and teacher of natural history in Illinois many most interesting and important parts of our local zoölogy which have hitherto been a sealed book to all except the expert with a special library at his command.

It will be seen that our season's work has fully opened up the field, and shown us what is necessary to the continuance and development of our enterprise. I am entirely satisfied with the locality, and wish to occupy it next year in a more permanent manner, with a view to continuous work there for several years, probably no less than five. The present arrangements, while fairly satisfactory for this preliminary year and clearly the best that could have been made, were very inconvenient in some respects, and wasteful of the time and strength of the Station force. The cabin boat on Quiver Lake was two and a half miles from town, and it was usually necessary for all but one or two to make this trip back and forth each day in skiffs. We consequently urgently need a small temporary building on the lake sufficient to afford office and laboratory room and living accommodations for the whole force. This building could be made capable of removal elsewhere if desirable. The

cabin boat leased this summer, although the best within our reach, was too small for our purpose and extremely uncomfortable in hot weather, the temperature in the working room often rising considerably above 100° Fah., and we should have a boat of this kind built especially for our purpose. This boat should be equipped with a larger experimental apparatus than we had this year, useful for a study of life histories, for a demonstration of the effects of changed conditions on various species kept in confinement, and for other similar work, by which alone clues may be found to the highly complicated and extremely difficult problems presenting themselves to the field observer. A great amount of time and strength has been consumed in rowing from station to station, where our regular collections were made, and we should have a small steam or naphtha launch or tug, able to weather the summer storms.

It has fortunately happened this year that changes in the University courses in my department have released the equipment and the corps of instruction of the zoölogical laboratories for the spring and autumn terms, and I have thus been able to borrow for the Station a part of the University material, and to assign to the Station work a part of our force engaged for other purposes. This will usually be impossible hereafter, and considerable additions to the Station equipment and a larger salary list will consequently be required. An estimate, in detail, of the appropriations necessary to make these improvements and carry out these plans has already been submitted to your Committee on Legislative Appropriations, and I will here only suggest that it seems to me desirable that the University and the State Laboratory should continue to share the labors and expenses of the Station, since its work is equally advantageous to the departments of instruction and to the Natural History Survey of the State.

THE CONTAGIOUS DISEASES OF THE CHINCH BUG.

As an important part of the work of the State Laboratory, I have further to report the experimental operations of the present year with methods for the prevention and arrest of ravages by chinch bugs in Illinois.

Since my first discovery, in 1882, of an unmistakable contagious disease of this insect (due to an Entomophthora), I have given prominent attention to the subject, greatly stimulated by observations made in 1887 and 1888 which demonstrated, quite to my satisfaction, the very important agency of these diseases in reducing to insignificance the most destructive outbreaks of this insect. It was in July, 1887, that I first found dead chinch bugs, evidently killed by a second fungus parasite (*Sporotrichum globuliferum*, Speg.), previously known as a botanical species, but not identified as the cause of the death of insects. The publication from time to time of the results of my observations and experiments strongly attracted the attention of economic entomologists to this subject, and published reports from other states—notably from Kansas—of the successful application of the germs of insect disease for the destruction of chinch bugs in the field aroused a widespread interest among farmers generally, frequently amounting to a confident belief that injuries by the chinch bug might be completely prevented by the distribution of diseased specimens in infested fields. The results of my own experiments did not by any means warrant this belief, but, as apparent at the beginning of the present season, had led me rather to conclude that the diseases at present known can be propagated among chinch bugs only under especially favorable circumstances, and that under those circumstances they are certain to appear spontaneously in our region, without very prolonged delay. Opportunities for experiment had been too few, however, in Illinois to warrant me in announcing this as a conclusion proven beyond dispute. I have consequently supplied to very many farmers of this State during the last two years numerous lots of infected chinch bugs, by means of which to introduce the contagious diseases of that insect into their own fields; but in so doing I have spared no pains to notify all concerned, both in official correspondence and by published circular, of the experimental character of the method, and of its hitherto variable, and as yet problematical, results.

A great increase of chinch-bug injury this season (1894) and the near prospect of very heavy loss throughout a large part of the State so greatly increased this demand upon me last spring for infection material that I was no longer able to meet it from current appropriations at my disposal, and with the aid of my

usual corps of assistants. I consequently suggested, early in June, to the authorities of the State Agricultural Experiment Station at Champaign, the idea of providing for more elaborate experiments in the field, and of supplying a limited amount of tested infection material for trial by farmers themselves. Under ordinary circumstances, of course, I should not have proposed this general supply to farmers until we had reached more definite and promising conclusions as a result of our own experimental work, but I was led to make this proposition this year by the following considerations:

1. I was not yet prepared to say positively that the contagious-disease method applied as in Kansas would not take effect in very many cases if persistently followed up. As long as there was even an appreciable chance that the farmers might thus save any considerable part of their crops this season by our aid, it seemed to me that they were entitled to the benefit of the doubt in favor of this procedure, especially as the expense of a general distribution would be, at most, a trifle compared with the great interests at stake.

2. The general credit which this method has received through the above-mentioned publications and through the agricultural papers and daily press, and the firm belief which very many of our farmers already had in it, made it seem very likely that nothing would satisfy them except a chance to try it.

3. I was reasonably well satisfied from our own field observations and laboratory experiments that, under favorable weather conditions, this contagious disease might do an immense service to those parts of the State threatened with the destruction of their wheat and corn; and as we could not foresee the weather of the season, I thought it incumbent on us to take measures to derive the greatest possible advantage from weather favorable to the disease, if such weather should follow.

4. I wished, finally, to see for myself how generally and accurately the somewhat complicated directions necessary to an intelligent use of this method would be followed out by the average farmer when greatly interested in the result.

This plan of experimentation and distribution was very promptly taken up and favorably considered by the Executive Committee of the Station Board, and I was authorized to spend in this direction not to exceed \$200 previous to

the meeting of the Board, June 1, and subsequent to that meeting \$250 more. I consequently engaged the necessary assistants, enlarged our facilities, and published a general notice to those interested of my willingness to receive live chinch bugs and return infected ones in their place, using for this purpose the Associated Press, June 5, 1894, and sending out through the Experiment Station office a press bulletin on "The Chinch Bug in Illinois," dated June 7. This offer was most eagerly accepted by a very large number of farmers, and we were presently very nearly overwhelmed—as were also the local express offices and the post-office—by packages of chinch bugs arriving from all parts of the State, and in all imaginable conditions.

In order to avail myself of the much larger experience of the Kansas Station, I followed precisely, at first, the infection methods there in use, depending upon an exposure of the chinch bugs to insects dead with the disease and covered with the characteristic fungus growth; and to make assurance doubly sure I had obtained a supply of material directly from the Kansas State University, although we had the same fungus in our own infection boxes at the time. Notwithstanding the great enlargement of our facilities, and the continuous expert attention which the whole subject received, especially from Mr. John Marten, who has had principal charge of our disease experiments for four years, the contagion did not spread rapidly enough in our boxes to make it possible to meet at once more than a small percentage of the demand. I found later that a part of this slow development was due to a difficulty which seems not to have been previously noticed by any one here or elsewhere; namely, the appearance in our infection boxes of swarms of minute mites which fed upon the fungus as fast as it was developed.

Next, observing that the thirteen-year locusts, which were rapidly disappearing, had many of them died with this disease, and bore a profuse growth of the characteristic fungus in excellent condition, I had a large quantity of these collected, and used these dead locusts for distribution, accompanied in each case by chinch bugs which had been exposed to the infection.

Finally, having ascertained, as a result of experiments made previously and also at the time, that the cultivated fungus grown upon a mixture of corn meal and beef broth is in every

way as effective for the destruction of chinch bugs as that obtained from the insects themselves, I had a large quantity grown artificially on this material, and used this also for distribution.

By these methods I succeeded, by about the 20th of July, in supplying all who had sent requests up to the 10th of that month—a little over two thousand for the season. As I had issued a second bulletin June 30, giving notice that it would be impossible to continue the distribution beyond July 10, I considered the obligations I had assumed thus fulfilled, and the work was brought practically to an end.

Each lot of chinch bugs, living and dead, was accompanied by the following circular of directions for their utilization and of caution against hasty observation and inference:

“STATE OF ILLINOIS.—OFFICE OF THE STATE ENTOMOLOGIST.”

CHAMPAIGN, June 20, 1894.

“DEAR SIR: I send you by this mail chinch bugs which have been successfully exposed to the white fungus disease of that insect, and are in a condition to convey it to others.

“To propagate this disease in your field, make a tight shallow wooden box, say, 24x36x6 inches, and place in it a layer of dirt half an inch deep, free from leaves or other rubbish. Moisten this dirt without making it muddy, and then put in a thin layer of green wheat or corn. Scatter the dead chinch bugs sent you over the bottom of the box, and shut up with them a quantity of live bugs from the field—as many as can well move about in the box without being anywhere more than one layer deep. Fasten the cover down tight, so that nothing can escape, and set the box where it will be protected from sun and wind. A cellar or a basement room is to be preferred.

“Open the box daily and moisten its sides and contents (without making them muddy) when they begin to get dry, and also change the food as that in the box becomes yellow. When it is seen that the white, mouldy bugs are becoming more numerous, probably in about three or four days, take a part of the bugs, dead and alive, out of the box, putting in fresh live ones to take their places, and close the box as before.

“Those taken out should then be scattered through the infested field where the bugs are thickest—at the bases of the

leaves in the corn fields, around the lower ends of the stalks, and the like. Make this distribution, by preference, in the evening, when the dew is on, or, still better, just after a rain, and repeat if dry weather follows. Continue these collections and distributions as above through the whole season, making certain each time chinch bugs are taken out that white ones are left in the box; and when winter comes put all the dead bugs remaining into pill boxes for use the following year.

“Those wishing to form an independent judgment of the practical value of this method of dealing with chinch bugs should take into account the following facts:

“1. The white fungus causing insect disease requires moisture for its full development, and especially for the formation of the minute “spores” by whose dispersal the disease is conveyed from one insect to another. In times of severe drought it propagates slowly or not at all.

“2. It takes effect on a weakened insect more readily than on one in full vigor; on the full grown chinch bug more easily than on the young; and hence most easily of all on spent adults which have already laid their eggs and are about to perish by the natural termination of their life period.

“3. It is a native disease of the chinch bug, and never dies out entirely, but is likely to appear spontaneously over a large extent of country when conditions favorable to its development are long maintained.

“4. Two generations of the chinch bug appear each year, and when each of these generations matures, the adult bugs commonly take wing and scatter, thus disappearing largely from fields or parts of fields heavily infested by them. Such dispersal has often been mistaken for a destruction of chinch bugs by disease. One generation matures shortly after wheat harvest and the other in late summer and in the fall.

“5. The chinch bug sheds its skin four times while growing, and the empty skins left by it are often mistaken for dead bugs—a mistake which has sometimes led to a false conclusion as to the effect of these infection experiments. The cast skins never bear wings, as the insect does not moult after its wings are formed. They may further be readily distinguished from the dead bugs by the fact that when pressed between the thumb-nails they are readily seen to be empty shells without contents.

“To judge intelligently of the effect of any attempt to introduce disease, the observer should examine very carefully, in advance, the field in which the experiment is to be tried, and adjacent fields as well, to see whether bugs dead with the white fungus may not already be present. If the disease appears at the point where the infected chinch bugs are placed, he should repeat this general examination, and make sure that the disease may not have occurred spontaneously and without special reference to his experimental introduction of it. He should also notice whether young bugs (those without wings) are attacked by it, as, if they are not, it is quite likely it is only carrying away those about to die of old age. On the other hand, it should be remembered that these especially susceptible adult bugs may afford the best means of securing a general dissemination of the fungus in the fields, where it may lie dormant for a considerable time, ready to spring into sudden activity when favorable weather conditions appear.

“Advantage should be taken of every considerable shower, and especially of every long rain, to scatter the diseased bugs, and all fields under observation should be thoroughly inspected some two or three days thereafter.

Very truly yours,

S. A. FORBES,

State Entomologist.”

I was also careful in every published statement or written communication on the subject to warn all against reliance upon this method to the neglect of other preventive or destructive measures, and emphasized in every way its purely experimental character.

In the meantime, experiments, carefully planned and closely followed up, were tried in the field by Mr. Marten and Mr. Johnson, both assistants of the office, by the distribution, in wheat and corn fields, of chinch bugs dead with disease and bearing the characteristic fungus in a fruiting condition. One such experiment was made on the University Experiment Station farm, at Champaign, and others were set on foot at several points in southern Illinois, each being followed up by repeated visits made to ascertain the result. One and all of these personally conducted field experiments failed absolutely, no ap-

pearance of infection or trace of disease appearing in any of the fields into which the infection had been introduced by us, until the advent of wet weather in the fall.

In southern Illinois the drought was generally severe in June and July, and I have little doubt that substantially the same unfavorable result followed upon nearly the whole mass of individual experiments made by farmers with the material sent from the Station. My previous experience with farmers' reports on this matter has led me, however, to attach but little importance to them, except where they can be sifted by cross-questioning and personal inspection. Opportunities for fallacious observation are unusually numerous here, and the whole subject is beset with difficulties quite sufficient to remove it beyond the reach of the ordinary untutored and unskilled observer. Numerous visits were made by myself and my assistants to those reached by our distribution, infection boxes were examined, field experiments were inspected, and many interviews were had with farmers themselves. While in many cases their infection boxes were working well, we have found but three fields in which the disease was successfully propagated this year. Even those in which it had appeared spontaneously early in the season—and a number of such fields were found—were so thoroughly dried up in June and July that the further spread of the infection was checked, and the disease disappeared entirely. We have certainly established by this summer's work the practical inefficiency of this method for the prompt destruction of chinch bugs in very dry weather, under conditions prevailing in Illinois this year.

The three exceptional fields above mentioned were widely separated, —one being near Farina, in Fayette county; one near Edgewood, in Effingham county; and the third near Odin, in Marion county. In all these cases the experiment was begun early in the season, and no result appeared until the late summer and autumn rains began—much too late to arrest or diminish injury to the crop of the present year. The number of chinch bugs dead with fungus disease in these fields this fall makes it quite possible, however, that they may give origin next spring to a general outbreak of the disease on the premises of these farmers which will do them important service. This is a conclusion less important than it would otherwise seem if it

were not for the fact that during our latest tour of inspection made to the infested part of southern Illinois (October 5 to 9) not a single field of corn was found anywhere, whatever may have been its situation or previous history, in which some trace of the disease could not be found among chinch bugs then remaining. It thus appears that conditions now are unusually favorable to an arrest next year of the prevailing chinch-bug outbreak, provided that the weather of the season is not too dry.

Far more promising and important than the above was a series of experiments made by us on the Experiment Station farm July 10 to 15, with methods for destroying chinch bugs as they leave infested fields of wheat at and shortly after harvest. By these experiments, thoroughly carried out under my own observation, I ascertained that chinch bugs can certainly be prevented at that season of the year from getting access to corn in any considerable number, and can be destroyed wholesale as they make the attempt to leave the wheat, at an expense far within the margin of economic operation. The method used was that which I have elsewhere characterized as the barrier method, the barrier in this case consisting of a strip of thoroughly pulverized earth with a deep, dusty furrow running through it, in the bottom of which, at intervals of about twenty feet, post-holes are sunk to a depth of a foot, or more. This makes a practically complete barrier and trap when the weather is dry, except that it requires the supervision of a man or boy for each eighty to one hundred and fifty rods. In wet weather a belt of coal-tar must be poured along the bottom of the furrow and renewed as may be necessary.

OTHER ECONOMIC INVESTIGATIONS.

Impressed by the serious and growing damage to nursery stock in central Illinois, due to certain insects which infest the freshest leaves and the tips of the twigs, I began this year a series of systematic experiments with measures of prevention and remedy in the insectary and in the field, which I intend to carry forward year by year until a definite result is reached. Similar work on grass insects was also begun last fall and continued for a time this spring. A study of the scale insects of the State has been taken up by my assistant, Mr. W. G. Johnson, and measures have been taken for a thorough investigation of insect

injury to grain and manufactured products in elevators and mills. An elaborate article by Mr. Johnson is now ready for the press, on the Mediterranean Flour Moth—a pest somewhat recently introduced into America, which has proven elsewhere capable of enormous and almost uncontrollable mischief in flouring mills.

PUBLICATIONS.

The final preparation for the press of my biennial entomological report for 1891 and 1892 was delayed by Exposition engagements and by other circumstances beyond my control. It is, however, now in the hands of the printer, and the report for 1893 and 1894 is far advanced towards completion. It will doubtless be ready for the press at the usual date. The same circumstances have delayed the publication of the second volume of the series of final reports on the zoölogy of the State, that concluding Mr. Ridgway's contribution to the ornithology of Illinois. It now awaits only the copying of certain plates, the originals of which were destroyed by fire in Springfield.

Additional papers, either prepared by the Laboratory force and printed elsewhere, or published in our Bulletin since my last report, are as follows: by the Director of the Laboratory, "A Preliminary Report on the Aquatic Invertebrate Fauna of the Yellowstone National Park, Wyoming, and of the Flathead Region of Montana," "The Progress of Economic Entomology during the Years 1891 and 1892," a "Presidential Address," read before the American Association of Economic Entomologists, August 14, 1893, and "Report of the Director of the Aquarium of the United States Fish Commission at the World's Columbian Exposition;" by Prof. H. Garman, "A Synopsis of the Reptiles and Amphibians of Illinois;" by Dr. F. W. Goding, "Bibliographical and Synonymical Catalogue of the Described Membracidæ of North America;" by Prof. G. H. French, "Description of two New Deltoid Moths;" by Mr. W. E. Loucks, "The Life History and Distribution of the Prothonotary Warbler in Illinois;" and, by Prof. C. W. Rolfe, "List of Altitudes in the State of Illinois."

REMOVAL OF LABORATORY.

Since my last report to you the State Laboratory has removed to the rooms assigned to it in the new Natural History Hall of the University of Illinois, five on the first floor and two in

the basement. These rooms are a Director's office, 21 ft. x 19 ft., a library room, 22 x 32, an assistants' laboratory 36 x 21, a collection room 61 x 36, two large store rooms, and a dark room for photography.

These rooms have been completely refitted with new furniture, made to our order especially for our purposes. The insectary (a separate building) has also been thoroughly refitted during the present year, and its office rooms refurnished and more completely equipped.

LABORATORY STAFF.

The Laboratory staff continues as in previous years, except that Mr. John Marten resigned August 15, after more than six years of faithful service as field entomologist; that Mr. W. G. Johnson was appointed July 1 as Assistant Entomologist to the Laboratory; and that Mr. Frank Smith, University Instructor in Zoölogy, has been assigned to the State Laboratory as Assistant Zoölogist for a part of his time, in place of Assistant Professor Summers. Mr. C. A. Hart, who has heretofore been our office entomologist, has been placed in immediate charge of all the Laboratory collections.

S. A. FORBES,

Director.

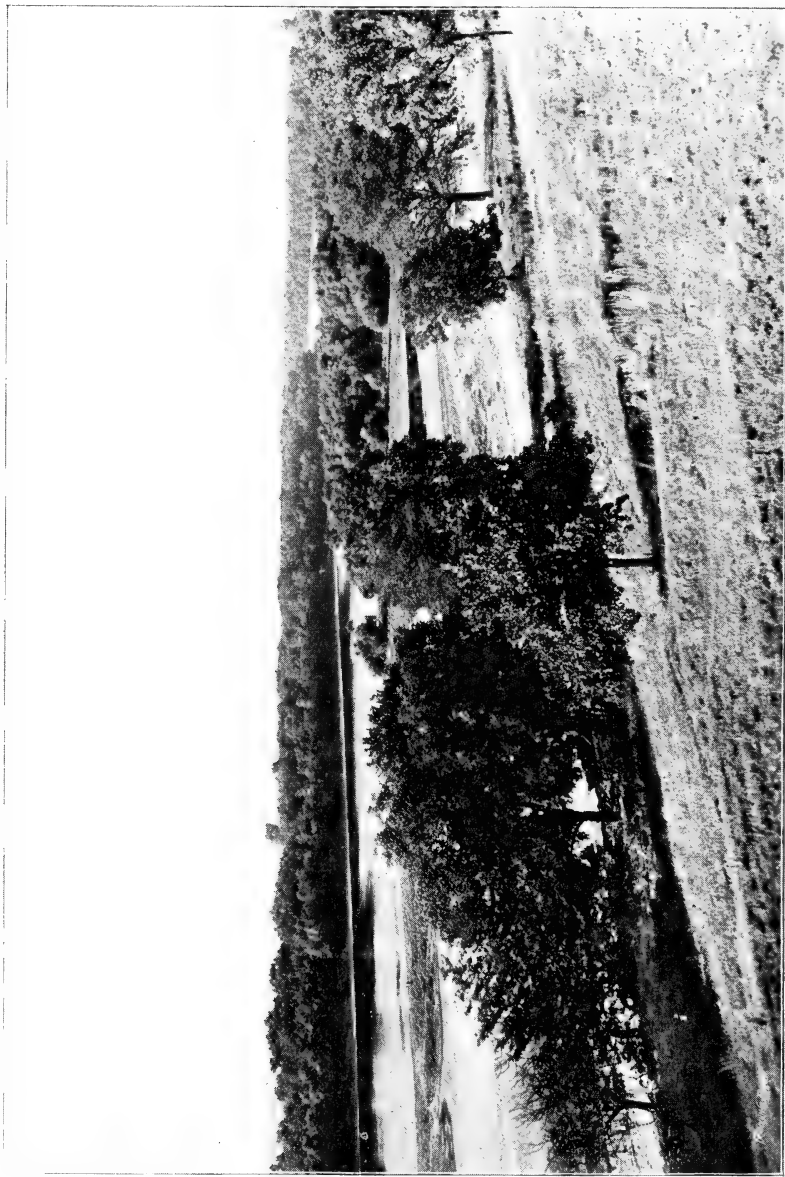
Nov. 26, 1894.



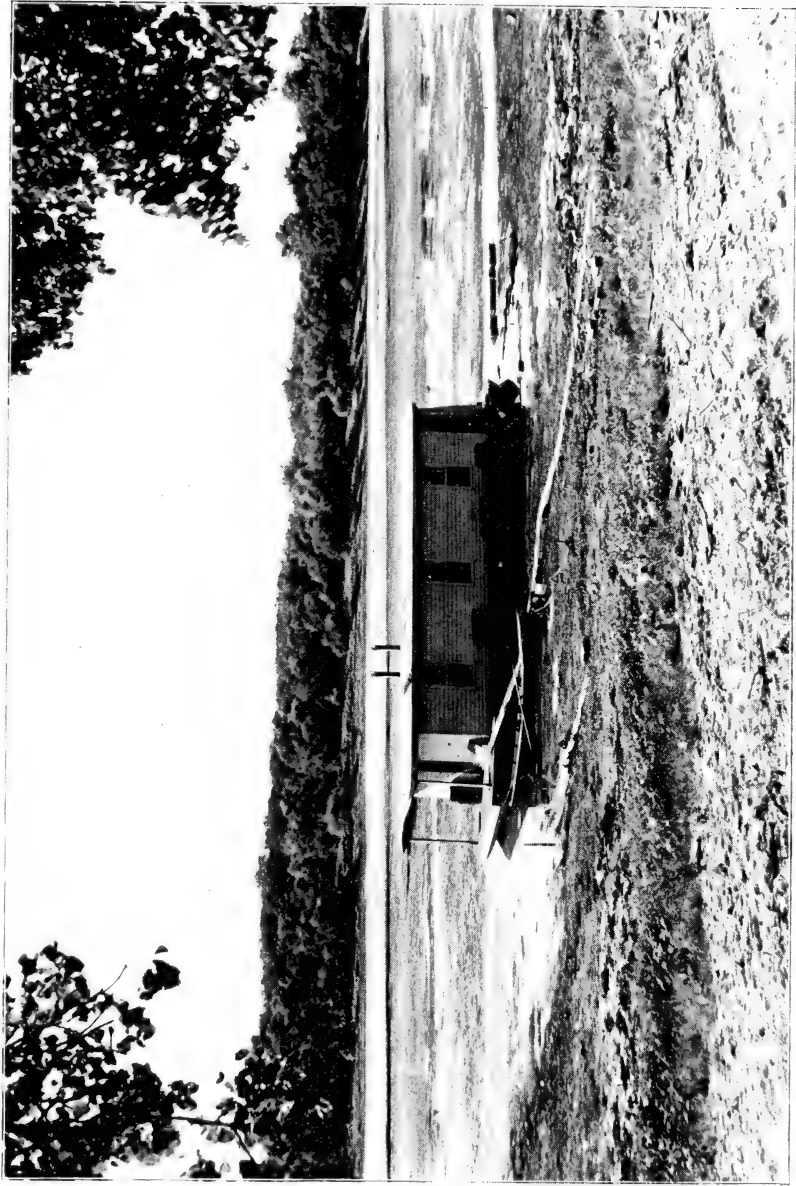
EXHIBIT OF STATE LABORATORY AND UNIVERSITY COLLEGE OF SCIENCE.
(Partial View)



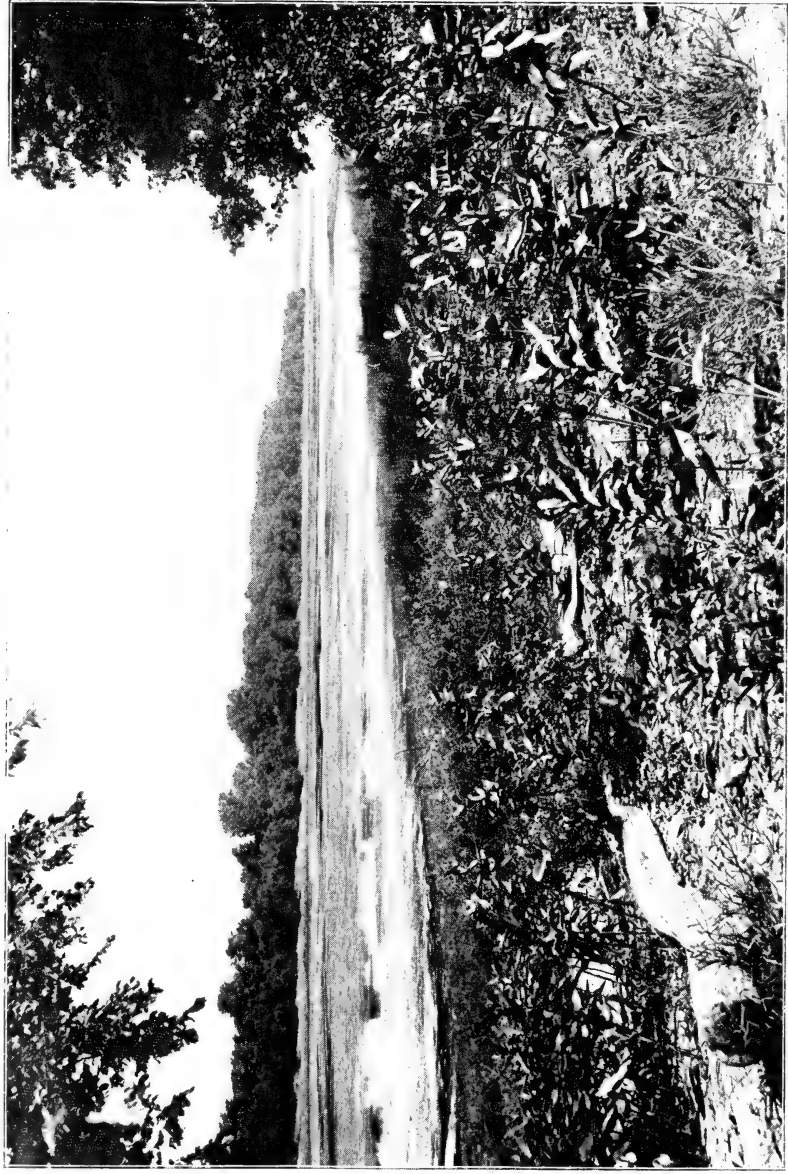
THE GENERAL SITUATION. QUIVER LAKE, ILLINOIS RIVER, AND THE ILLINOIS BOTTOMS, FROM THE EAST BLUFF



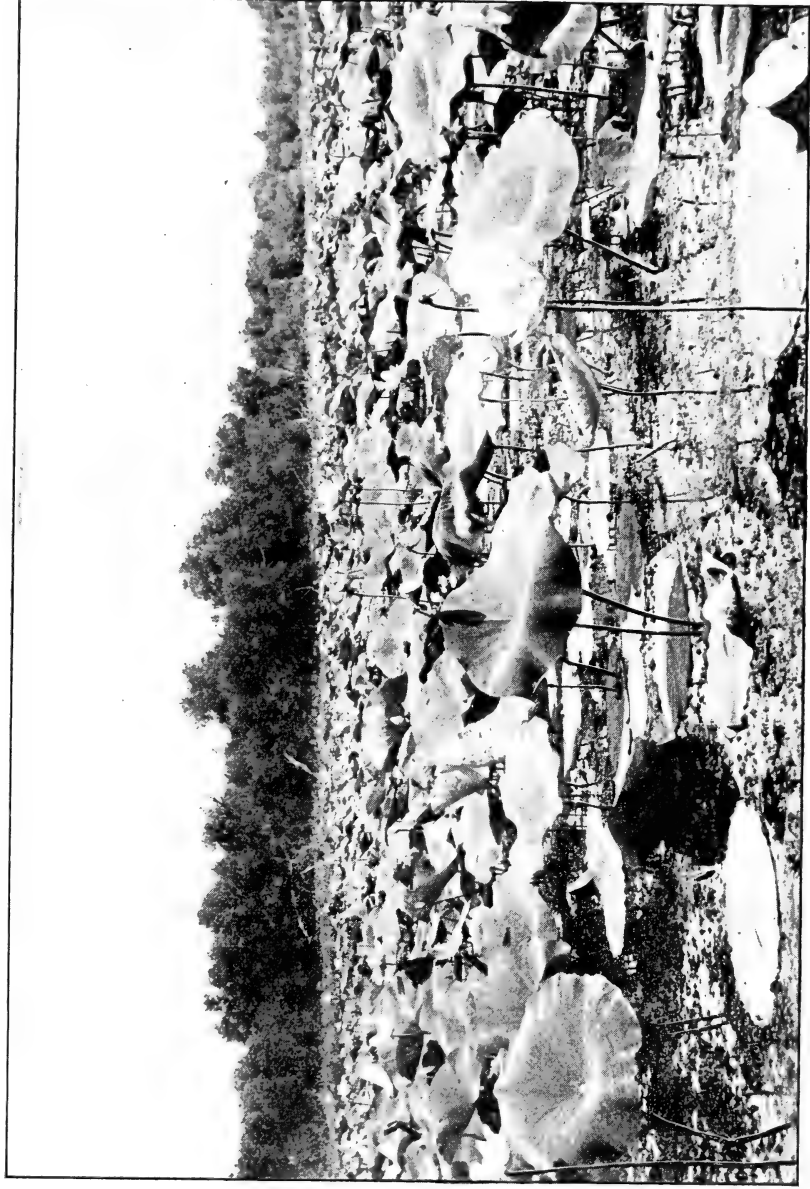
THE GENERAL SITUATION. UP THE ILLINOIS RIVER FROM THE EAST BLUFF.



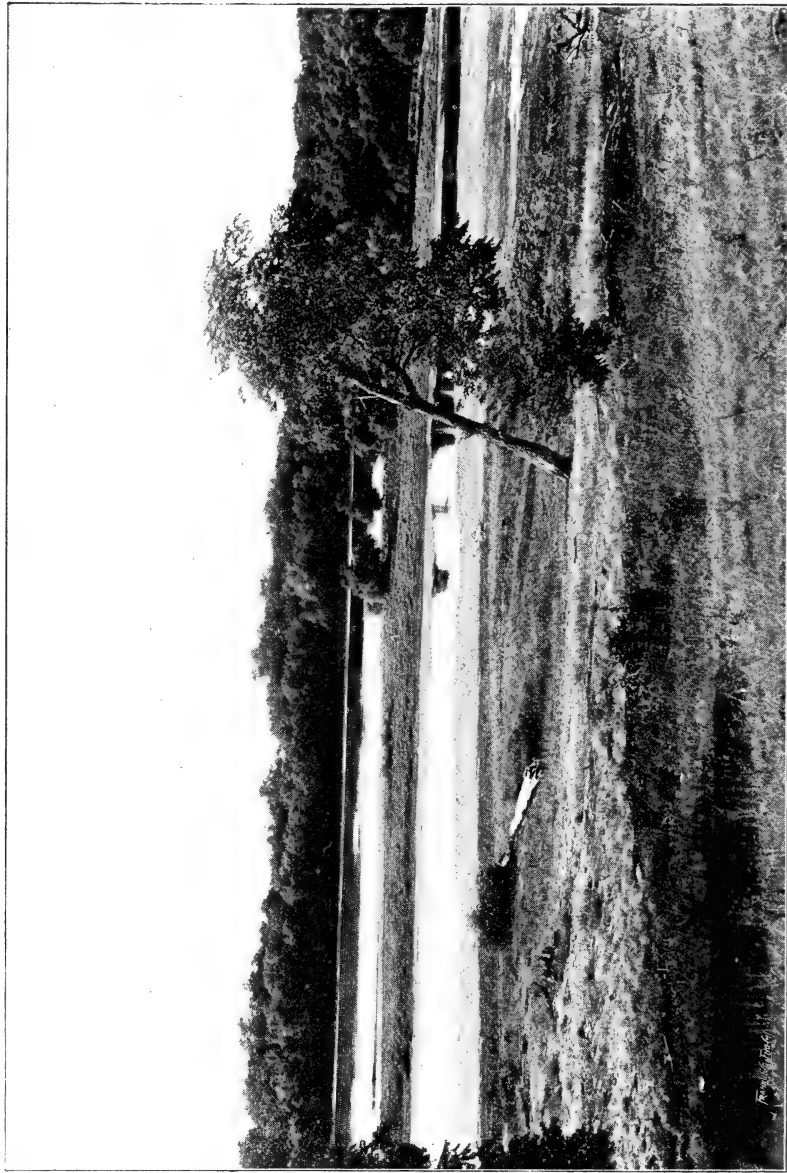
FIELD HEADQUARTERS, QUIVER LAKE (STATION C).



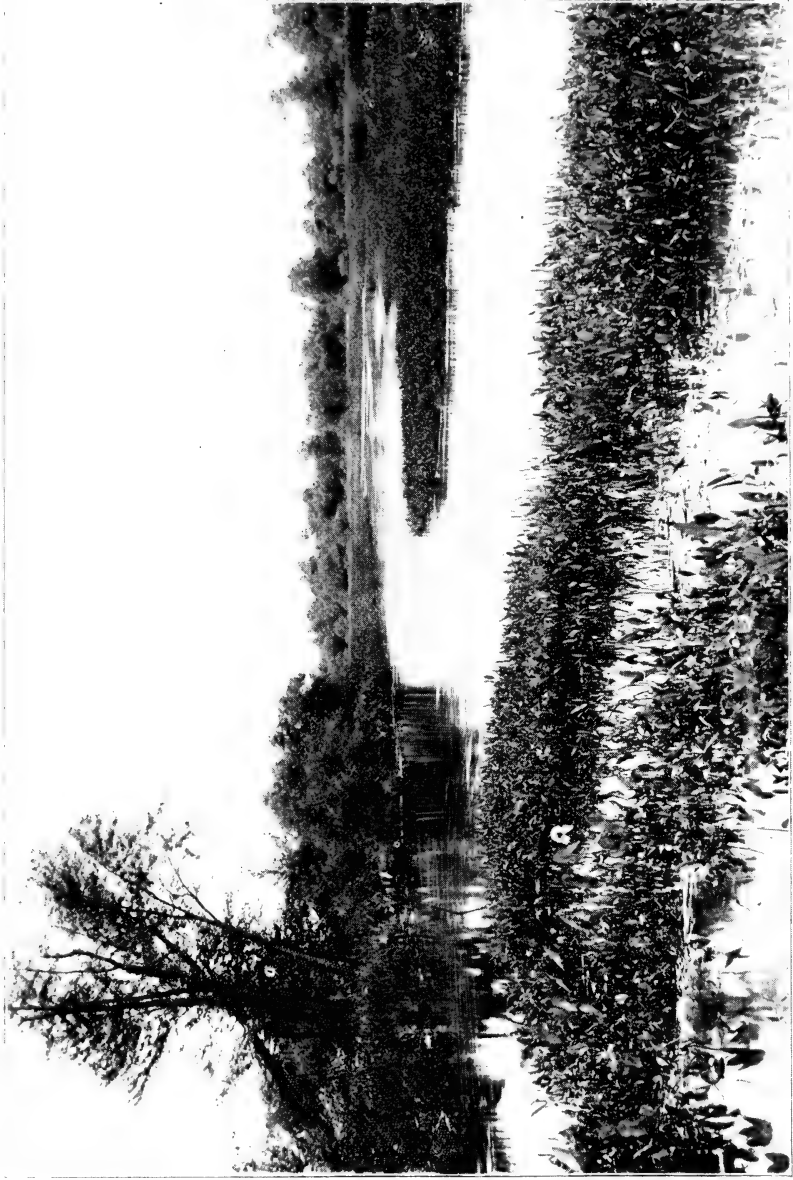
VIEW UP QUIVER LAKE FROM STATION C.



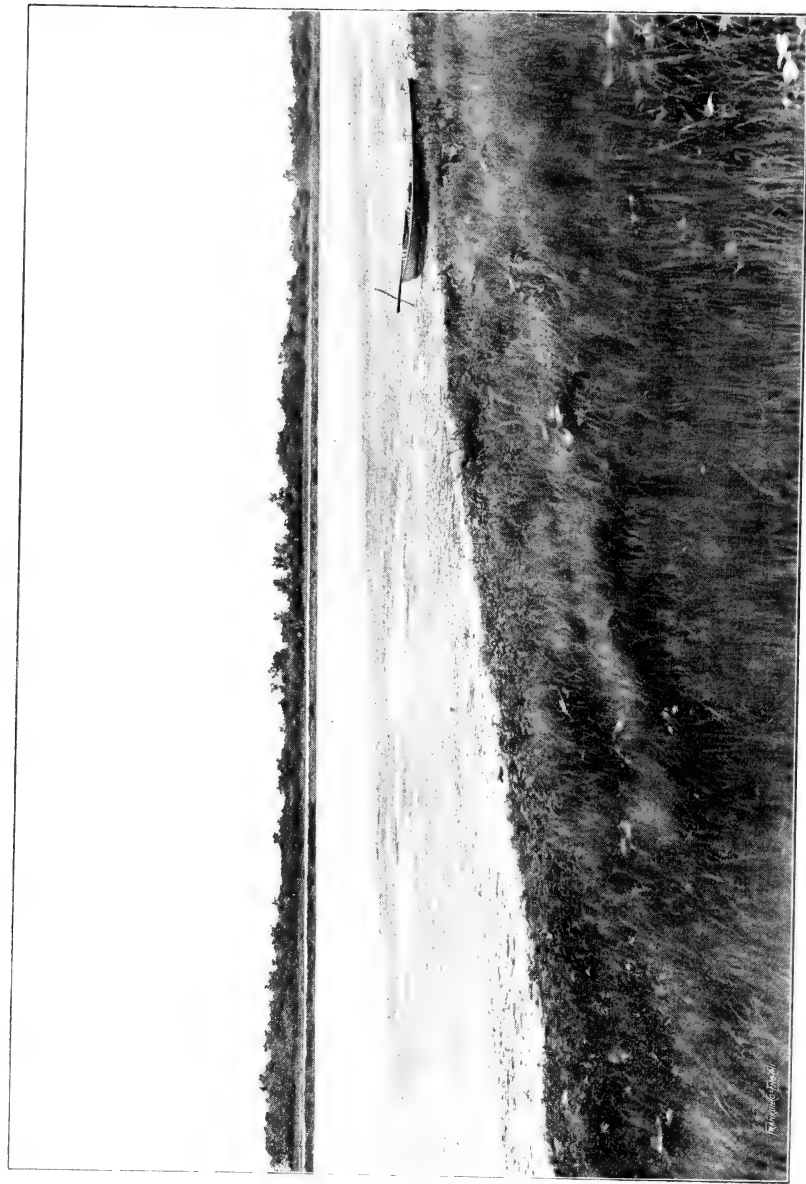
LOTUS BED, NEAR HEAD OF QUIVER LAKE, WEST SIDE.



QUIVER LAKE AND ILLINOIS RIVER, FROM EAST BLUFF, BELOW STATION C.



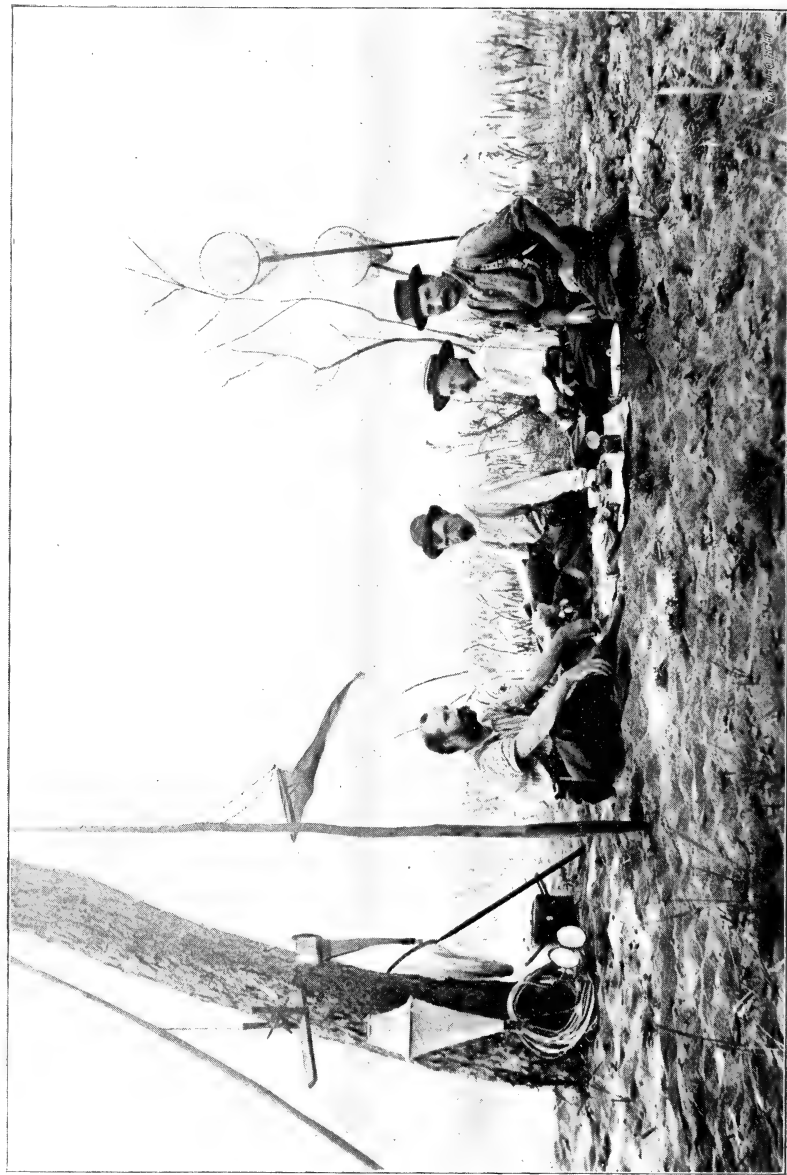
QUIVER CREEK, NEAR ITS MOUTH.

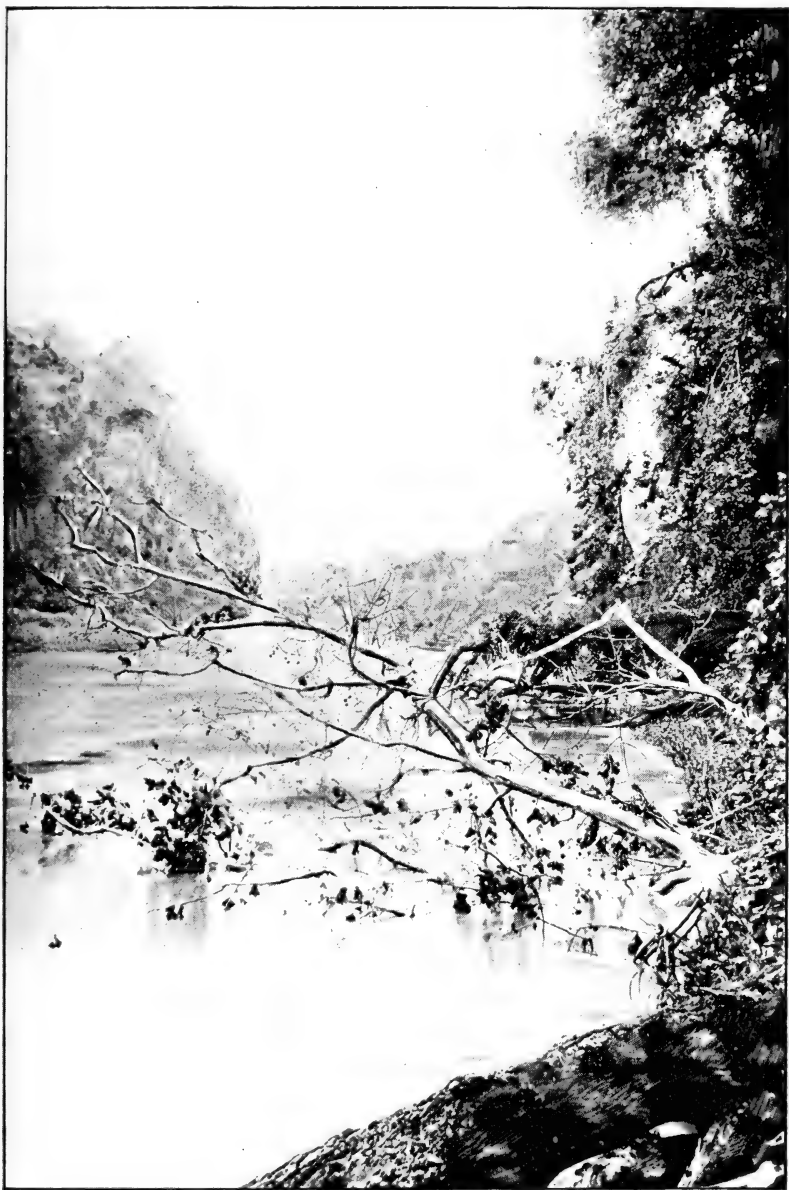


ILLINOIS RIVER ("HAVANA LAKE"), STATION D.

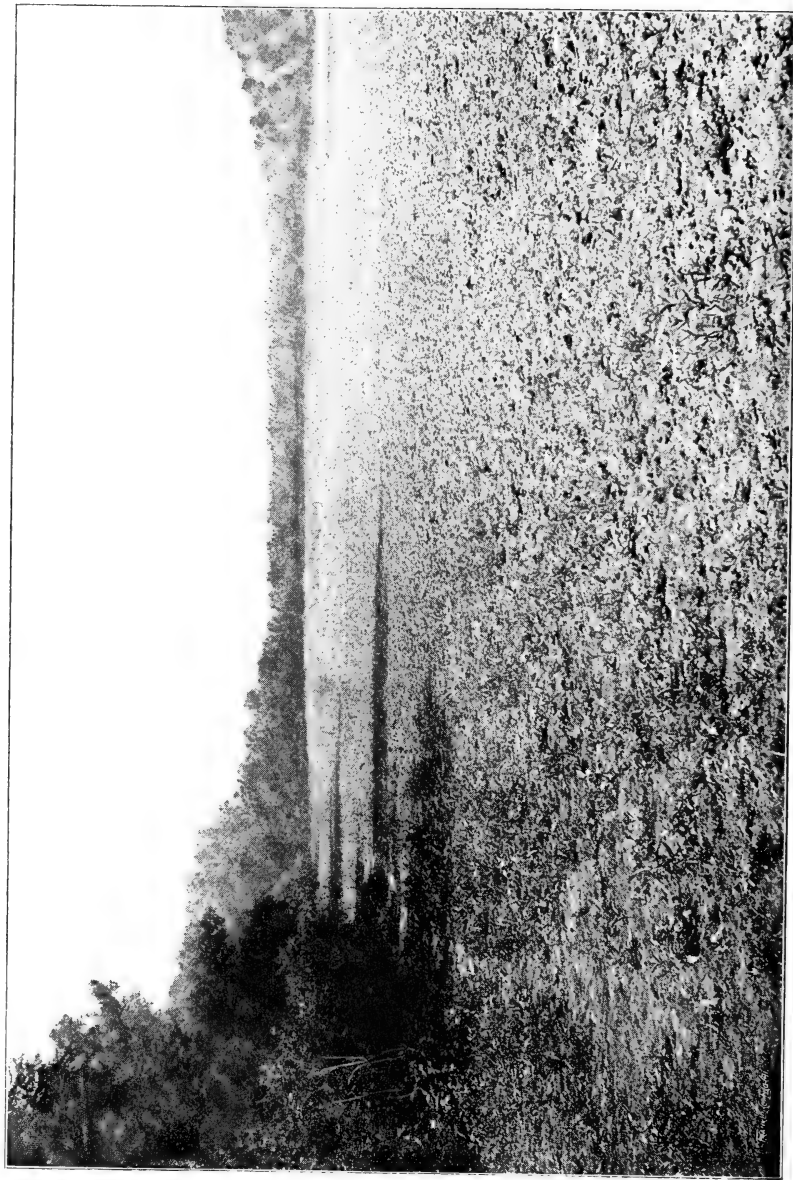


THOMPSON'S LAKE (STATION G). ALONG-SHORE COLLECTING.





SPOON RIVER, NEAR ITS MOUTH.





BED OF PHELPS LAKE. LAST POOLS REMAINING.





ACROSS MATANZAS LAKE, NEAR MIDDLE.

LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

6
25-26

ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY
URBANA, ILL.

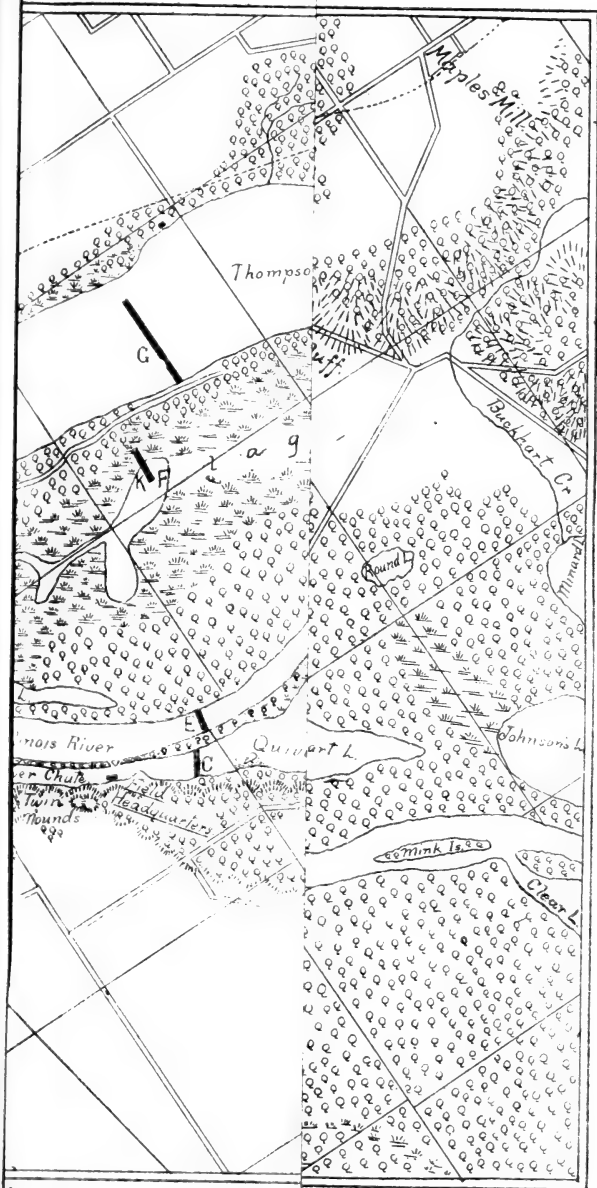
BIENNIAL REPORT
OF THE
STATE LABORATORY
AND
SPECIAL REPORT
OF THE
UNIVERSITY BIOLOGICAL EXPERIMENT STATION.

1895-1896.

SPRINGFIELD, ILL.:
PHILLIPS BROS., STATE PRINTERS.
1896.

ON OPERATIC

STAFF.

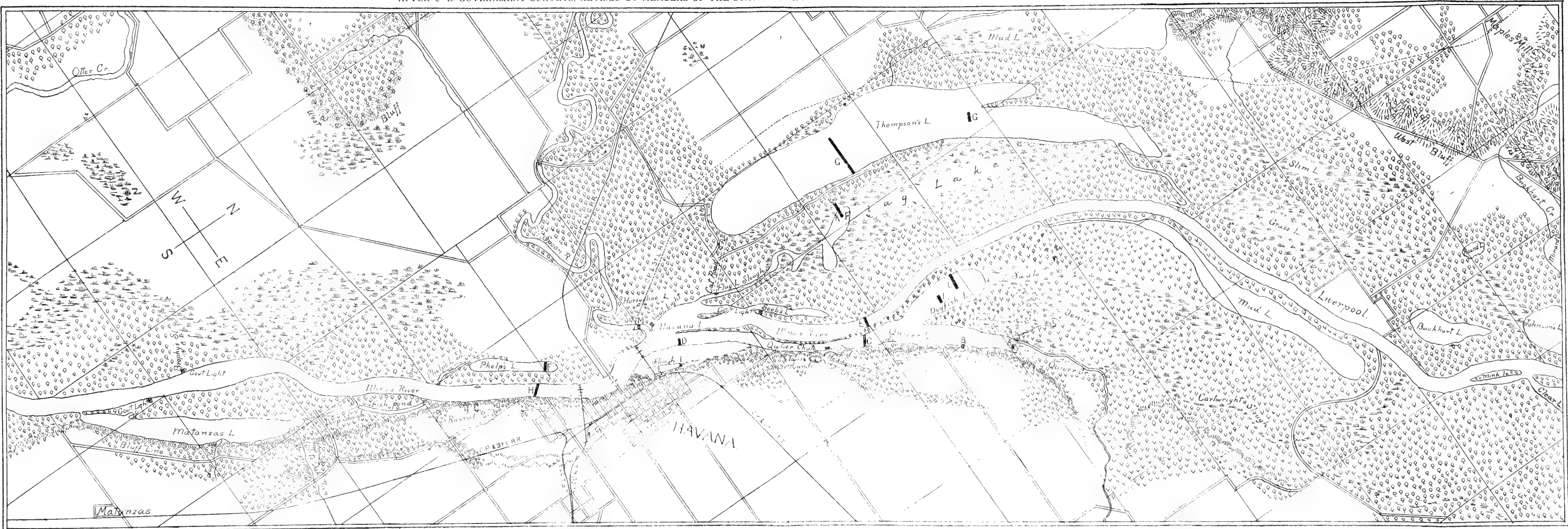


of Miles.

FIELD OF BIOLOGICAL STATION OPERATIONS. LOW WATER.

AFTER U S GOVERNMENT SURVEYS, REVISED BY MEMBERS OF THE STATION STAFF.

DRAWN BY LYDIA M. HART.



Wagon Road
Bluff
Substation.

1/8 1/4 1/2 1
Scale of Miles.

Marsh
Forest
Sandbar.

ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY

URBANA, ILL.

BIENNIAL REPORT

OF THE

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AND

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1895-1896.

SPRINGFIELD, ILL.:
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1896.

State Laboratory of Natural History.

LABORATORY STAFF.

PROFESSOR STEPHEN ALFRED FORBES, Ph. D., Director of
Laboratory and State Entomologist.

FRANK SMITH, A. M., Assistant Zoölogist.

CHARLES ATWOOD KOFOID, Ph. D., Superintendent of Bio-
logical Station.

CHARLES ARTHUR HART, Systematic Entomologist and Cura-
tor of Collections.

WILLIS GRANT JOHNSON, A. M., Assistant Entomologist.*

WILLIAM APPLETON SNOW, M. S., Assistant Entomologist.

ADOLPH HEMPEL, B. S., Zoölogical Assistant.†

BENJAMIN MINGE DUGGAR, A. M., Botanical Assistant.**

CHARLES CHRISTOPHER ADAMS, B. S., Entomological As-
sistant.††

HENRY CLINTON FORBES, Librarian and Business Agent.

LYDIA MOORE HART, Artist.

MARY JANE SNYDER, Secretary.

*Resigned June 30, 1896.

†From July 1 to November 20, 1896.

‡To September 1, 1896.

**From July 1, 1895, to May 31, 1896.

††Since November 3, 1896.

BIENNIAL REPORT
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY

To the Trustees of the University of Illinois.

GENTLEMEN: The operations of the State Laboratory of Natural History during the past two years have been carried successfully forward along the customary lines of investigation, with a notable expansion, under the stimulus of appropriations made by the last legislature, in the study of the contagious diseases of insects and in the work of the Illinois River Biological Experiment Station.

The insect-disease work took during the summer of 1895 the direction of an investigation of the causes of our general failure in field experiments with white muscardine of the chinch-bug, together with an investigation of a newly discovered disease of the common squash-bug. Among additional subjects studied, was a destructive disease of grasshoppers in the West, material for which was obtained from a correspondent in Colorado, and the so-called white lague of the common cabbage worm.

The general result of our studies of the white muscardine has been to discredit still further the practical utility of that disease for field operations on a large scale. In consequence of this outcome very few distributions of infected material have been made from my office during 1896, and those only in response to direct requests from farmers. The material sent out has been accompanied, as in all my previous sendings, with explicit warning to the effect that no definite reliance was to be placed on it, but that its use was to be regarded as an experiment only. It now seems quite clear, as the general result of all our investigations of this complicated subject, that the circumstances under which artificial field infection of chinch-bugs with the white-muscardine fungus will take practical effect in a way to produce any important benefit are at least so rare and unusual that the whole subject must at present be assigned to the limbo of unverified theories.

A more promising result was obtained from an investigation of a bacterial disease of the common squash-bug, which proved to be highly contagious and

promptly fatal under laboratory conditions closely similar to those obtained in the field. A laboratory study of this disease, and of the organism characterizing it, was completed by my assistant in this department, Mr. B. M. Duggar, and his paper on the subject is now going through the press.

During the present season particular attention has been given to a new disease of the army worm, which had the effect to destroy the greater part of the individuals composing an outbreak of this species early in the present year; and to a critical study of occurrences connected with a general disappearance of the chinch-bug, or the marked diminution of its numbers, in regions where it was abundant last year, and where it made a threatening beginning this spring. Careful and systematic studies have been made to determine, so far as practicable, the precise causes of this diminution in numbers in the field, and particularly to ascertain whether contagious diseases, bacterial or other, not hitherto detected, were now discoverable. The results have been thus far either negative or incomplete, the death of chinch-bug being due, so far as observed and determined, either to the direct effect of the weather of the season or to one or both of the two contagious diseases of that insect thus far known to us. Some of our experiments are, however, still incomplete, and certain clues in my possession, when followed out, may possibly lead to other conclusions.

The work of the Biological Experiment Station has made very satisfactory progress under somewhat embarrassing conditions, due especially to insufficiency of funds for the continuous maintenance of our work on the scale originally planned. The equipment fund has all been expended in the building and furnishing of a laboratory boat as a field headquarters and students laboratory, in the purchase of a launch and in the substitution of more powerful machinery for that originally furnished with it, and in the purchase or manufacture of various pieces of apparatus required for our peculiar work.

Owing to the practical exhaustion of funds, the laboratory boat, established for the summer on Quiver Lake, was brought down to Havana September 1, 1896, and placed, together with the launch, in charge of our general Station assistant, Mr. Newberry, who takes the responsibility of the care and protection of all our Station property during the fall and winter at a salary of \$25 a month. The work of the Station is not, however, completely suspended. The Superintendent, Dr. Kofoid, visiting Havana once a fortnight for the usual systematic round of observations, collections, and other operations, at the various substations in our field.

The Station bills are all paid except a few recently received, in process of payment now, and there is a comfortable balance in the appropriations for the current year beyond those covered by expenditures to which we are committed. In accordance with your authorization at your last meeting I have discontinued Mr. Adolph Hempel's services, simply because it was impossible to continue his salary with our funds, and have engaged Dr. Kofoid as Station Superintendent at his former salary, to June 30, 1897.

Full particulars concerning the scope of our operations, the amount and character of the work done, the results now ready for report, the papers

completed, and those published or in press, I ask leave to file as a special supplementary report, for general circulation. I should be glad to have your order for a separate print of a thousand copies of this report, with illustrations, to be separately bound in pamphlet form at the expense of the State Laboratory of Natural History. I will only say now, in general, that the conclusions already reached, especially in Dr. Kofoid's department of so-called plankton work, cannot fail to command the close attention and strong interest of scientific men, the world over, engaged in investigations of this class.

The summer opening of the Station to investigating and other independent students resulted in the acceptance of our invitation by twenty-two persons, seven of whom were finally prevented from attending. Our accommodations were limited to fifteen workers additional to the Station force, but as the seventeen who arrived did not all present themselves at once, we were able to provide satisfactorily for them. These seventeen visitants represented the States of Ohio, Michigan, Illinois, Iowa, Nebraska, and Utah. Eight were members of college or university faculties; five were teachers of biology in high schools or academies; two were city school superintendents; and two were college students in advanced courses. The colleges and universities presented by them were the Wesleyan University, at Bloomington, Ill.; the Nebraska Wesleyan University; Carthage College, at Carthage, Ill.; Knox College, at Galesburg; Lincoln University, at Lincoln; Eureka College, Eureka; Cornell College, at Mt. Vernon, Ia.; Drake University, at Des Moines, Ia.; the University of Utah, Salt Lake City; and the University of Illinois. The high schools and academies sending instructors to the Station were University School, Cleveland, O.; Detroit High School, Detroit, Mich.; the Public High School at Dwight, Ill., and the high schools at Havana, Ill., and Marshalltown, Ia.

They were a competent and energetic group of students; a credit to the Station, and in some respects an aid rather than a hindrance to our work. Two of them, Professor Kelly, of Cornell College, Iowa, and Mr. Beardslee, University School, Cleveland, Ohio, are preparing papers presenting the scientific results of their Station investigations, which they have kindly placed at my disposal for publication in the State Laboratory Bulletin as a part of the series of papers growing out of the Station work. Our summer visitants were, I think without exception, pronounced in their appreciation of the opportunity offered them, and emphatic in their expressions of surprise at the attractiveness of the situation and the richness of the biological field in which the Station is established. Several of them have already filed requests for admission next year.

The success of the "Summer Opening," together with several conversations which I have had with teachers of biology, public school superintendents, and the like, have convinced me that it is incumbent upon us, if in any way practicable, to extend this offering of an opportunity for midsummer work to public school teachers of biology, and I have taken some preliminary

steps to that end. As this is purely instructional work, however, it does not fall within the province of the State Laboratory of Natural History, but belongs to the University relationship, and need not be discussed in this report.

The general entomological work of the State Laboratory has been mainly economic in purpose, and as it will be reported by me to the Governor, I do not include it here.

Respectfully submitted,

S. A. FORBES,

Director of Laboratory.

SPECIAL REPORT

OF THE

BIOLOGICAL EXPERIMENT STATION.

To the Trustees of the University of Illinois.

GENTLEMEN: The Biological Experiment Station of the University of Illinois was founded mainly to represent the University and the State in an important field of Scientific investigation; to do its part towards making the people of the state at large acquainted with the State itself, to stimulate and to aid the educational activities of the public schools in respect to the biological subjects and to reform, in some respects, their methods; and to put a foundation of precise and comprehensive knowledge of the system of aquatic life under the practical art of the fish-culturist, especially as this is represented by the operations of the Fish Commissions of our interior states.

It hardly need be said that an educational institution may not properly assume and keep the name of university which is content to depend wholly on the abilities and activities of others for the store of knowledge which it distributes to its students, contributing nothing on its own part to the common stock. Such a condition of complete dependence marks it as at best a secondary school. It is also beneath the dignity of a sovereign state to depend wholly on others for the fundamental elements of its welfare, making no effort to render any return in kind. On the other hand, a state university owes its first duty to the people of its own state, and should investigate by preference subjects which concern their welfare. Even though it may do valuable work in remoter fields, it neglects its own sphere of essential and immediate usefulness if it lets its own territory remain unexplored, and its own special problems lie without solution.

The teaching of biology has been for many years required in the public schools of Illinois, but it is a commonplace complaint that this work is far less valuable than it should be, and that its progress is grievously hampered because most of our teachers of science have a very imperfect acquaintance with the subject-matter which should be taught and with the most fruitful methods of biological instruction. The University of Illinois, through its

Biological Station, can do a great service to education at this juncture by opening up our local natural history to teachers of elementary biology, and by making them acquainted in a thoroughly practical way with the most useful special methods in this field. We seem just now, indeed, in admirable position to lead the way along a new line of progress by helping to bring teacher and pupil, under favorable conditions, into the presence of living nature out of doors, adding to the methods of the class room and the laboratory of biology those of observation, study, and instruction in the field.*

The art of the fish-culturist is to our waters what the art of agriculture is to our tillable lands. Each was in the beginning purely empirical, resting on a small store of common knowledge gained by the crude experience of the uneducated and the untrained. Agriculture has now been largely placed on a scientific foundation, and vigorous efforts are making all over the civilized world to extend, to deepen, and to render more exact in every direction our acquaintance with the sciences which underlie the practice of this oldest of the arts. The development of fish-culture has, however, lingered far behind that of its companion subject, compared with which it is indeed still in the stage of barbarism. We treat the product of our natural waters with a degree of intelligence and skill scarcely above that which the Indian exhibited in his rude attempts at agriculture before the time of Columbus. Our Biological Station was founded in part with the hope of helping to do for fish-culture what our forty or more agricultural experiment stations are now doing for the agriculture of the United States.

To accomplish these various ends, it was necessary that a subject should be chosen and that a location should be found offering a suitable field for scientific research of a kind to reward the skilled investigation with results of scientific value, and that these results should also interest a larger public than that which is prepared to appreciate and to utilize purely technical work. It was essential that this location should be readily accessible from the University, and that it should be attractive, comfortable, and convenient as a center of operations for visiting investigators and for general and elementary students of our field biology. The purposed relation to fish-culture of course required that it should be on or near some lake or stream, or, better still, on some system of waters including both lakes and streams in large variety and in close proximity. After a careful study of the University environment, I selected in 1894 the Illinois River and its dependent waters as our general field, and the vicinity of Havana, in Mason county, as the principal seat of our operations. Our two years' experience here has served only to confirm our first impression, that a very suitable and, indeed, highly fortunate selection had been made.

* A genuine field-work summer school would be as far ahead of laboratory work for teachers—the class who are wrestling with nature study in the grades—as the laboratory is ahead of the old-fashioned text book. It would be a distinct advance upon anything ever attempted, so far as I know, in this country.—WILBUR S. JACKMAN.

LOCATION AND FIELD OF OPERATIONS.

The Illinois River near Havana has a maximum width of about five hundred feet at the lowest stage of water, and a maximum depth at that stage of approximately ten feet. For a distance of about five miles, at the town and above and below, it runs along the foot of a steep sandy bank or bluff, ranging from forty to eighty feet in height, itself the edge of an extensive deposit of glacial sand extending with little interruption some seventy miles along the eastern side of the river, and perhaps a dozen or fifteen miles in width from east to west. The bottom of this bed of sand is not anywhere exposed near Havana and has not been reached, so far as I have learned, by any borings in that vicinity. From the foot of the bluff, at or near the water's edge, is a more or less general oozing of clear cold water sometimes flowing forth in springs of considerable size and sometimes forming small marshy tracts between the river and the bluff.

The opposite or western bank of the river here is of black earth, the border of an alluvial bottom three or four miles wide, in which are several ponds and lakes and through which Spoon River winds its way, entering the Illinois nearly opposite the town. At the upper end of this five mile stretch the river leaves the sandy bluff, having thence alluvial banks for some distance northward. The remnant of an old river bed continues upward, however, from this point along the bluff in the form of a narrow bay one and a half miles in length, the so-called Quiver Lake, open to the river below, and receiving Quiver Creek at its upper end. This creek, largely formed by the drainage of a sandy tract to the east and north, empties into the broad and shallow head of the lake through a muddy and weedy flat. Quiver Lake, like the river below, has a sandy bank and margin on the east, and a mud bank on the west. The natural drainage of the sand escapes in large quantities along the eastern side of this lake, keeping the shore constantly saturated with cold water, to a greater or less width according to the level of the lake, and modifying greatly, when the river is low, the character of the waters of the lake itself. A broad bay of this Quiver Lake extending to the west from near its middle, forms what is known as Dogfish Lake, with shores of black alluvial earth all around.

The other waters of the vicinity included in the system of Station operations are Thompson's Lake, a shallow body of water about five miles long by one mile wide, lying in the bottoms near the western bluff; Flag Lake, a shallow muddy pond or, more correctly, a marsh, about three miles in length, largely overgrown in summer with the club-rush, water-lily, and arrowleaf; and Phelps Lake, a small pond of dead water, three fourths of a mile in length, with almost no vegetation, in the midst of a densely wooded bottom-land.

The field headquarters of the Station party, the summer location of the laboratory boat, was at the foot of Quiver Lake, against the sandy eastern bank. The top of the bluff is here wooded at the edge and for a variable distance back with oak and hickory and ash and other common hard-wood upland trees. Cottonwoods, walnuts, locusts, coffee-trees, elms, and pecans of

a considerable size, extending in a rather ragged line, offer a very welcome shade at the foot of the bluff at about high-water mark. An abundant supply of very pure and delightfully cool water is easily reached everywhere, either in running springs or by driving down an iron pipe for a few feet in the sand and screwing on a common cistern pump.

The occasional narrow, swampy flats along the eastern bank of Quiver Lake and beside the river between that lake and the town, are usually tangled thickets of underbrush and swamp-land trees, which at certain seasons of the year are gay with multitudes of flowers and vocal with the songs of a great variety of birds. The general aspect of the flora of the sandy bluffs is quite unusual for Illinois, many plants occurring there abundantly which are rarely seen in ordinary situations. The bottom-lands become covered in late summer and autumn with an immense growth of composite plants, setting the intervals and recesses of the forest ablaze with yellows, purples, and reds, and loading the air with the heavy odor of the upland *Eupatorium*.

This forest itself, beginning at the water's edge with a billowy belt of pale green willows, is an untamed tract of primitive wilderness, differing from that through which the Indian hunted his prey only by the absence of the small percentage of its growth which had a commercial value. Subject to periodical overflow, it has not even been fenced. Elms and pecans and sycamores tower overhead or slowly moulder where they fall, and vines and creepers clamber over the underbrush in a growth like that of a semi-tropical jungle. The shallow lakes and swamps are glorious in their season with the American lotus and the white water-lily, the former sometimes growing in tracts of a hundred acres or more, over which its gigantic peltate leaves, borne on tall slender stems, flash in the sun as they bend to the summer wind. In July and August many of the lakes are nearly filled with submerged vegetation, and in the latter part of the season a film of the duckweeds forms along the shore and floats in large patches down the sluggish current of the stream. Water-fowl abound at the period of their migrations, and fish lie on the shallows, basking in the summer sun in numbers such that dozens may be seen at a time as one floats along in a boat.

The microscopic life of the water is equally varied and abundant, a measurement of the quantity present in a cubic meter of water showing that with a single reported exception* it is at certain times far in excess of the amount recorded for any other situation in the world. The variety of species present is equally remarkable. The list of those occurring in a single cubic meter of water from the river at Havana in the month of July contains about twice as many as any of the lists of those found at the same time in the lakes of northern Germany or in our own Great Lakes.

The bluff beyond the bottoms to the west is higher than that on the east, and usually of a very different character. Strata of carboniferous rock, sometimes containing veins of coal, outcrop locally near their base, while the

* Dobersdorfer See, Holstein.

higher slopes are formed of yellowish clays, ditched and gullied by the rain, with occasional small streams flowing through gorge-like valleys from the level uplands of the country farther west.

The description thus far given applies to the lower stages of water only. When the river is at flood the entire bottom-land from bluff to bluff is often wholly under water, lakes, streams and marshes being then confounded in one unbroken sheet from three to five or six miles across. As the river level varies some eighteen feet between high and low water mark, it may reach in its deepest part a depth of nearly thirty feet. These periods of inundation are very commonly two in a year, one beginning in late winter or spring with the melting of the snows, and the other coming most frequently in June or July, as a consequence of the early summer rains. The rise at either or both these periods is occasionally so small that no very marked effect on the biology of the river is produced. It was, in fact, fortunate for our operations that the first two years of our occupancy of the Station were marked by this comparative uniformity in the river level. Observations and collections made at this time have given us a fairly steady biological base line, by comparison with which variations in other years may be detected, due to extensive overflow and subsequent recession of the waters.

The plan and purpose of our work was such as to make it necessary that we should choose a number of regular stations—called substations in our reports—at which collections should be made and observations placed on record at regular periods for the entire year, and one year after another. These substations, thirteen in number, were chosen to represent the greatest variety of biological situations which the territory within our reach would permit. They have been sufficiently characterized in the introductory part to a report by the Station Entomologist, Mr. C. A. Hart, on the entomology of the Illinois River and adjacent waters, published in the Bulletin of the State Laboratory of Natural History in 1895. It may be said in general that the substations chosen represent the springy bank and sandy margin of Quiver Lake and of the river itself in both swift and sluggish water, the opposite mud bank of river and lake, shallow mud flats overgrown with water weeds, the bed of river and lake in the deepest water occurring, and three forms of bottom-land lakes, together with a fourth occasionally visited. Thompson's Lake gives us a permanent body of water of some little depth, always opening into the river, even at its lowest stage, but contrasting with Quiver Lake in the fact that this opening is long and tortuous, while in the latter it is half as broad as the lake itself. Matanzas Lake, on the eastern side of the river but below the town, is substantially intermediate in character between these two. Like Quiver Lake, it has a high, wooded, sandy eastern shore and low forest-covered mud banks on the west, with an inlet at the head, which is, however, smaller than Quiver Creek. The flow of spring water from the sand is much more abundant. Like Thompson's Lake, its outlet is narrow, but it is very short. This lake commonly has more vegetation than Thompson's and less than Quiver Lake. In Flag Lake we have little more than a fairly permanent swamp, subject, indeed, in extraordinary years to be dried out completely,

but overflowed again from the river at every slight rise. Phelps Lake, on the other hand, serves as an example of the highly variable conditions prevailing in a pool filled up at every general overflow, but isolated on the retreat of the waters, and drying out entirely in the very driest years.

ESSENTIAL OBJECTS.

It is the general, comprehensive object of our Biological Station to study the forms of life, both animal and vegetable, in all of their stages, of a great river system, as represented in carefully selected typical localities. This study must include their distinguishing characters; their classification and variations; their local and general distribution and abundance; their behavior; characteristics, and life histories; their mutual relationships and interactions as living associates; and the interactions likewise between them and the inanimate forms of matter and of energy in the midst of which they live. We are, in short, to do what is possible to us to unravel and to elucidate in general and in detail the system of aquatic life in a considerable district of interior North America.

So vast a subject must of course be intelligently divided and studied part by part, in some systematic order, to avoid a dissipation of effort and to insure the speedy attainment of some definite and tangible results. Its most obvious divisions are the systematic, the biographical, and the œcological; and this is the order, broadly speaking, in which the general investigation must be carried on. Both systematic and biographical biology have a high independent value in our scheme, but both are with us chiefly means to the remoter end of a study of the interactions of associate aquatic organisms, and of their relations to nature at large. It is thus the œcological idea which is to lead in the organization and development of our work. A systematic survey of the biological assemblage is a necessary preliminary step and the tracing of life histories and the recognition and description of immature stages is a scarcely less essential prerequisite; for without the knowledge which these studies are to give us, it would be obviously impossible to make any comprehensive study of variations, distribution, and œcological relationships.

The œcology of the Illinois River is greatly complicated, and the difficulty of its study intensified, by certain highly and irregularly variable elements of the environment. Apart from those secular and more or less inconstant features of climate and weather which must be taken into account wherever such studies are prosecuted, we often have here the evidently very large and highly intricate reactions produced by periodic variations in the river level, and the consequent enormous extensions and corresponding diminutions of the mass of the waters and of the area covered by them. Fortunately for the possibilities of success in so difficult a field, progress in it does not require that the entire system of life should be studied as a unit at first. Special problems may be selected, of a kind to be brought easily within the available time and the capacities of the individual investigator, which, being worked out one by one, may be later brought together as contributions to a

solution of the larger problems involved. While it is true, for example, that nothing in or about the waters studied which in any notable way affects any of the great groups of the system can be wholly a matter of indifference to the scientific student of fish-culture, the interests of every species being more or less intimately bound up with the interests of every other, yet provisional conclusions, at least, with regard to this, that, or the other kind of fish, or with regard to fishes at large, may be reached which will have considerable practical value, long before the entire system of interactions and relationships is fully understood. It is not necessary that we should know the food of every species of fish in the locality before we can generalize profitably the food relations of any one, although inference from such provisional generalizations must always be held subject to modification as our knowledge of related matters grows. A similar remark may be made with respect to such purely scientific matters as the limits and causes of variation, a very useful knowledge of which may be acquired without a full and final theory of variation in general.

In actual practice it has been found that our work may best be opened up by comprehensive studies of the classification such as will give us a critical knowledge of all the forms occurring in our field, and access to the published literature of each; and by parallel or slightly subsequent studies of their habits, life histories, and local distribution and abundance.

GENERAL METHODS.

The principal methods of the Biological Station are those of field and laboratory observation and record, collection, preservation, qualitative and quantitative determination, description, illustration, generalization, experiment, induction, and report.

By close and persevering observation in the field, we learn much of the actions, habits, and haunts of animals, of the special conditions under which they live and of many similar matters which cannot possibly be learned in any other way; and not a little of this knowledge is necessary to an intelligent treatment of both general and special problems in biology.

The acute, persevering, sympathetic observer of living nature—the “old-fashioned naturalist,” in short—is best to be understood as a “synthetic type,” all of whose best qualities should be not only preserved but intensified among his variously differentiated progeny. If I may generalize my own experience, I must say that it is extraordinarily difficult at the present time to find for this work the trained and intelligent naturalist, habituated to the methods of the close observer, whose eye nothing escapes, but whose mind rapidly and skilfully sifts the miscellaneous offerings of his senses, holding the significant and suggestive, and letting slip the trivial and the unessential. There seem to be among our younger college men ten practical embryologists to one good observer. It is, in fact, the biological station, wisely and liberally managed, which is to restore to us what was best in the naturalist of the old school united to what is best in the laboratory student of the new.

On the other hand, the variety of uses which must now be made of preserved material in the course of our Station studies necessitates the frequent employment of the nicest methods of the histological laboratory, and a complete acquaintance, at least, with laboratory methods in general.

Definite and precise comparisons of different aquatic localities with respect to their biology have first been made possible in some considerable measure by the comparatively recent introduction of more or less exact quantitative methods for the collection and determination of the biological contents of the water. These, commonly known as plankton methods, enable us also to study the biological history of any locality to which they are fully applicable, by making it possible to bring into close comparison the organic contents of the water from day to day, from season to season, and from year to year. Unfortunately, these methods are not as yet capable of application to all aquatic forms in all situations, but have been used successfully only for the smaller plant and animal forms of the clear open water.

By using always identical apparatus in a perfectly uniform manner for the accumulation of microscopic and semi-microscopic objects in such waters and preserving the product by identical methods, it is possible to make and keep collections which may serve as a means to a precise comparison of the mass of organic life in the waters studied, or of the number of individuals representing any selected species.

In our own Station work these plankton operations have been carried forward from the beginning at all the substations where open water could be found in condition to permit the hauling of our plankton net, or, later, the use of the plankton pump. A large number of quantitative determinations of collections so made have been worked out in a way to give the actual quantity of organic life in a cubic meter of water for each situation studied by this method, and enumerations of various forms have likewise been made under the microscope by methods such as to give us reliable data for a comparison of the various waters with reference to the number of such forms in a cubic meter of water. Approximately quantitative collections have likewise been made, wherever possible, in situations which do not permit the use of this plankton apparatus, but with results far less reliable, of course, because based mainly on personal estimates, and made by the use of less precise and exhaustive methods.

It seems not impossible that quantitative and numerical plankton work will be found to have a certain value as a ground of inference concerning the biological contents of water which cannot be searched by the plankton apparatus. In other words, definite, if general, relationships may be found to exist between the amount and composition of the plankton in the free and open water of a given lake or stream at any given time and the mass and variety of living forms contained in the marginal shallows or imbedded in the mud of the bottom.

Considerable modifications have been made at the Station since it opened, in the details of the quantitative method, often forced upon us by the peculiarities of the location and the special conditions under which our work was

carried on, and interesting improvements in special apparatus have resulted from the effort to overcome our peculiar difficulties. A paper on our plankton methods and apparatus is now in course of preparation by the Superintendent of the Station, Dr. C. A. Kofoed, to whom this department of the work has been assigned.

As our work progresses and special problems are taken up for separate and continuous investigation, the experimental method will necessarily come prominently into use. The object of biological experimentation is the interpretation of nature, and, like all intelligent experimental work, it must be suggested and guided by observation and hypothesis. With us it is the ecological field in which experiment is especially called for. Given certain phenomena of local distribution, of relative abundance, of association, of habit, of variation, and the like, whose causes it is desirable to ascertain, it is incumbent upon us, by a critical and exhaustive study of the environment to find the materials for rational hypotheses as to such causes, and to test such hypotheses by experimental procedure. It is thus always the field observation, or the laboratory observation made under conditions which involve the least practicable departure from natural conditions actually existing, which must precede and suggest the experiment. The method and the general object of this work resemble thus more closely, on the whole, those of the agricultural experiment station—which is, indeed, a biological station under another name and devoted to a special end—than those of the laboratory of experimental physiology; and it is because ours is to be in the end and in its final objects a station for the solution, by experimental methods, of both special and general problems in the field of ecology that it was christened by its official board of control the *Biological Experiment Station of the University*.

EQUIPMENT.

The main features of our present equipment are the laboratory boat and its contents, the steam launch, a number of skiffs, and the apparatus and belongings of the Illinois State Laboratory of Natural History and of the biological departments of the University of Illinois, both of which are placed, without restriction, at the service of the Station force.

THE FLOATING LABORATORY.

Our ultimate objects do not limit us to any single field, but will eventually compel us to transfer at least a part of our operations to other points for purposes of comparison and contrast. Indeed, the Illinois River work is but a convenient point of departure for an investigation of the whole Mississippi River system. These facts have made necessary for us a movable construction of considerable size, carefully designed and thoroughly equipped for our work. Furthermore, the great changes of water level and the enormous expansion of the area covered at flood in the region over which we operate, would make a location on shore oftentimes extremely inconvenient as working quarters for our Station force. There is a great advantage also in a position

in the very midst of our field, where contact with the objects of our interest must be almost continuous. It seemed, consequently, clear that a house-boat or so-called cabin boat of special construction, furnished as a biological laboratory, but with an equipment for minor experiments also, would meet our needs far more precisely than a building on shore.

This laboratory boat, launched in April, 1896, was built at Havana from plans drawn up under my direction by Messrs. Gunn and McLane, of the architectural department of the University. A strong built hull of Washington fir supports a deck 20x60 ft., upon which is a cabin 16x56 ft. In building the hull extraordinary pains were taken to obtain a steady construction. A three-inch solid bulk-head was run lengthwise through the middle, and two keelsons divide the space between this central bulkhead and the gunwales. Lateral strength was given by four series of diagonal braces, set as shown in Plate VI, and placed every two feet, and by three hog-chains run from the bottom of each gunwale over the middle bulk-head. As a consequence, the floor of the boat proved to be remarkably steady, no tremor being noticeable in the use of the higher powers of the microscope on minute objects suspended in fluids. The interior of the hull is ventilated by means of four hatchways with movable covers, two at each end of the deck.

The cabin has six large windows on each side, made freely movable for ventilation, and also transom ventilators above the windows. The roof is penetrated by four large ventilators and walls and roof are made double, as a protection against the heat, by ceiling with Georgia pine. By virtue of these arrangements the laboratory rooms were remarkably comfortable during even the hottest weather of the year.

The interior of the cabin is divided into four rooms; an office and library at one end 11 feet and 6 inches by 16 feet, occupied by the Station staff; a main laboratory 29 by 16 feet, primarily for visiting students and for the experimental equipment; a kitchen 8 feet and 8 inches by 12 feet, with gasoline stove and other cook's equipment, in which mid-day meals can be prepared for the Station force, and a small closet or store-room adjacent. The main laboratory is provided with tables, two to each window, and with shelving against the walls for books, note-boxes, specimens, etc., while down the center of the room is a sink table 3x22 feet, covered with zinc and furnished with a water supply for numerous small aquaria. A long overhead zinc-lined tank is supplied by iron piping, with a screw end outside the boat to which the discharge pipe of a hand force-pump can be readily attached. Stopcocks and glass and rubber tubing make the necessary connections with the tanks and jars used for aquarium work, the overflow being carried off by drainage pipes which empty outside the hull. The space beneath the central table is enclosed with doors and provided with shelves for general storage.

The boat has no motive power but is intended to be towed from place to place as occasion requires. Our steam launch "Illini" proved, indeed, to have sufficient power to transport this boat under ordinary circumstances.

This launch, built by the Racine Boat Manufacturing Company, of Racine, Wisconsin, is 25 feet long by 6 foot beam and is licensed to carry seventeen persons. The machinery furnished with it was replaced during the summer by a compound engine of four and a half horse power, with keel condenser. Both boiler and engine were designed by Assistant Professor VanDervoort of the University department of mechanical engineering and the engine and the speed propeller were made under his direction at the University shops. The launch was not designed especially for speed, the distances to be covered in our work being usually very short. It gives us, however, a rate of about six miles per hour. It is entirely safe in all weathers to which it may be exposed in our situation—a point of special importance to us since our regular routine of field work must be carried out without reference to storm or temperature. Four skiffs of various sizes and a portable canvass boat complete the aquatic equipment.

The more peculiar items of the field and laboratory apparatus are the plankton equipment, the breeding cages for the aquatic insects, and a specially constructed centrifugal machine for the rapid precipitation and condensation in graduated tubes of the product of quantitative collections. This last is a modification of the centrifuge used by physicians, the tubes and tube carriers being the same, but the mechanism being specially designed for us by Proessor VanDervoort and made under his supervision at the University shops. The plankton apparatus first used consisted of a peculiar conical net (Apstein pattern) made of No. 20 silk bolting cloth. This was hauled through the water obliquely from bottom to top, a distance of thirty metres, at a perfectly uniform rate, the movement being timed by seconds counted with watch in hand. The net was suspended to a carrier and drawn along a tightly stretched line, to which it was hung by means of pulleys, the various particulars of the arrangement being devised by Assistant Professor Smith, in charge of the plankton apparatus and the Station itself during the first year. In May, 1896, this plankton net was superseded by a hand force-pump, selected after considerable investigation of various styles, of a size and weight to be conveniently managed in a large skiff. The feed pipe of this pump is long enough to reach the bottom in our deepest water and the discharge pipe delivers into a straining net suspended in the water from a float to secure the contents of a vertical section. The further end of the feed pipe is sunk to the bottom and slowly raised to the surface, the pump being meanwhile worked by an assistant in a perfectly regular manner. Minor features of the apparatus and items of the procedure will be described in a special paper on our Station methods, now in course of preparation by the Station Superintendent.

For keeping insect larvæ under perfectly natural conditions but exposed to continual observation small cubical boxes were used, with two sides and the bottom of wood and the other two sides of wire gauze, and a cover of glass set in a wooden frame which overhung the top of the case, fitting closely to the sides. These cases were placed around a large float in the lake or river in such a manner as to be kept about half full of water, which ofcourse had free access through the wire gauze sides.

The laboratory boat was amply stocked with compound and dissecting microscopes and a supply of chemicals, glassware, and apparatus for the preservation of specimens and for microscopical technology. It was equipped for fifteen workers in addition to the Station staff. The excellent working library of the State Laboratory of Natural History was freely drawn upon for everything needed in aid of the special work in progress at the time and the library appropriation of the Laboratory was also used as necessary to supply desiderata. This aquatic establishment was found in all respects so satisfactory and convenient, that rented rooms in the town, similarly furnished, were presently abandoned by the entire party, all preferring to work upon the boat.

ORGANIZATION AND STAFF.

The staff of the Biological Station is composed of the Director and certain Assistants of the State Laboratory of Natural History, all of whom are appointed by the Trustees of the University of Illinois, and all except the Director upon his nomination. This officer is responsible for the organization, equipment, and general and financial administration of the Station, for the plan and objects of its operations, for the establishment and assignment of departments, for the main features of the papers and reports, and for the editorial supervision of the Station publication. The Superintendent, who is appointed as such officer, although borne upon the list of the assistants of the State Laboratory, has immediate charge of the Station force and is responsible to the Director for the execution of its plan of operations. He is allowed a large latitude with regard to details and in the absence of the Director all the workers at the Station are under his immediate orders.

From the establishment of the Station in April, 1894, until June 30, 1895, Mr. Frank Smith, at first Instructor and later Assistant Professor in the University department of zoölogy, served as Superintendent, devoting his time continuously to Station work until January 1, 1895. He had special personal charge of the quantitative collections—the so-called plankton work—during this period. He also began during the summer of 1894 a systematic study of the oligochaete worms of the Station and its vicinity, which he has continued to the present time, giving to this subject his vacations entire, and such time as is left him after the performance of his duties in his University department. He was assisted in his work from May to September, 1894, inclusive, by Mrs. Dora Smith who served the Station as its microscopical technologist during that period. Beginning with July 1, 1895, the Station has been in charge of Dr. C. A. Kofoid as Superintendent with the planktology of the situation as his special department. He also acted as superintendent of construction during the building of the laboratory boat. His entire time has been given to the Station work, except for the teaching of one University class for one term, undertaken as an exchange of services with the zoölogical department.

The entomological work has been, since the commencement, in charge of Mr. C. A. Hart, Systematic Entomologist of the State Laboratory, assisted

for two of the summer months of 1895 by Mr. Ernest B. Forbes. Mr. Hart's share in the regular routine of Station operations has been the making of the inshore and longshore collections at the various substations. In addition to his studies of the habits and life histories of aquatic insects, he has listed the Mollusca of the collections from the beginning. From September 8, 1894, to July 1, 1895, he was the sole continuous occupant of the Station, being responsible during that period for the regular field work, carried on with the assistance of visiting parties from the State Laboratory at Urbana.

Mr. Adolph Hempel was engaged without interruption upon a study of the Protozoa and Rotifera of the Station from its opening to June 1, 1896. At this time the condition of his eyes forbade further use of the microscope and he was placed in charge of the Station launch as its licensed engineer. He occupied the Station alone during the winter of 1895-96, keeping up, with such assistance as it was necessary to engage from time to time, the regular routine of collections and observations at the various substations.

Miss Lydia M. Hart, Artist of the State Laboratory, has devoted a large part of her time to drawings in illustration of the various papers prepared by the Station force. She was at Havana during about a month of 1895, the remainder of her work in this direction having been done at the State Laboratory.

Mr. Ernest B. Forbes has served during the vacation period of three seasons, the first as a general zoölogical assistant, the second as an assistant in the entomological field work, and the third in making a special study of the Cyclopidae of the Station collection.

Periodical chemical analyses of various waters collected at the Station have been made, from the first opening, under the direction of Professor A. W. Palmer, of the chemical department of the University of Illinois. Mr. C. F. Hottes, Botanical Assistant in the University, made several trips to the Station with Superintendent Smith during his regular visits in the winter of 1894-95 and both he and Professor T. J. Burrill, of the University department of botany, have made occasional collections of aquatic plants.

Mr. Miles Newberry, an experienced fisherman of Havana, has served the Station very efficiently from the beginning as a general assistant. He has been particularly serviceable as an aid in plankton work and has had immediate charge of the boat and of the aquatic equipment generally.

GENERAL EXHIBIT OF RESULTS.

Although the first report of results accomplished in a field so extensive and complicated as that occupied by our Biological Station must necessarily be largely an exhibit of work in progress, it seems possible to make a statement which shall give a comprehensive, if somewhat indefinite, idea of the outcome of operations thus far undertaken. This report may be made most conveniently under the heads of plankton operations, collections accumulated ento-

mological studies, molluscan collections and determinations, fresh-water worms, studies of Protozoa and Rotifera, chemical determinations, reports and publications, and the summer opening of the Station.

PLANKTON OPERATIONS.

The minute plant and animal life suspended in the waters of a river system, moving downwards with its current and washed to and fro by its waves, composes what is known to the modern biologist as the plankton of its waters. The Station operations in this field were primarily directed to a study of the amount of this plankton in the various locations selected, its seasonal and other periodic changes, its local and vertical distribution, its composition as to the species represented, and its relation in the general system of aquatic life. Our field of operations is a unique one, as yet practically untouched by the scientific investigator, in so far as it is limited to a river system and its dependent waters.

The plankton substations in 1894 and 1895 were five in number, one in the river, a short distance above the foot of Quiver Lake, another in Quiver Lake itself, a third in Dogfish Lake, a fourth in Thompson's Lake, and a fifth in Flag Lake, between Thompson's Lake and the river. To these were added in 1896 a substation at Phelps Lake, from which, indeed, a single quantitative collection had been made in 1894, and another in Spoon River a short distance above its mouth. From these various substations a thousand quantitative collections have been made since the Station opened, those from April, 1894, to June 30, 1895, by Professor Frank Smith or under his immediate direction and those subsequent to that time by Dr. C. A. Kofoid. All these tows have of course been carefully preserved by methods such as to permit their quantitative comparison and about three fourths of them have been quantitatively determined by Dr. Kofoid by methods of precise measurement. A considerable beginning has also been made in the enumeration of their contents by counting under the microscope.

Various modifications of plankton methods, elaborate tests of the apparatus used and of the methods of discussion current, and other items of improvement in the equipment and in the methods of planktology will be reported by Dr. Kofoid in a paper on this department of our work now nearly ready for the press. For certain general conclusions of considerable interest and of at least provisional value reference may be made to the same paper.

COLLECTIONS ACCUMULATED.

The total number of lots of specimens collected since the opening of the Station amounts to 6,628, besides 5,500 pinned insects. Of the former, 434 lots contain materials for a study of the food of animals, 300 of them being the contents of the stomachs of fishes; 270 are specimens of vertebrates; 3,560 are preserved collections of invertebrate animals; 1,823 are towing-net collections; and 543 were collections of Rotifera and Protozoa, most of which were studied alive because incapable of satisfactory preservation. The entire

number of collections, including under this head each object or lot of objects specially numbered and separately entered on our notes or in the accessions' catalogue of the Station, is thus nearly 12,000. Besides these mention should be made of about 400 microscopical slides of serial sections of oligochaete worms made for Professor Smith in the course of his studies of that group.

LIST OF COLLECTIONS.

Shallow-water collections with Birge net.....	232
Qualitative collections with surface net.....	592
Quantitative collections with plankton apparatus.....	999
Protozoa and Rotifera, collections.....	543
Vermes, collections.....	490
Crustacea, collections.....	167
Arachnida, collections.....	235
Insecta (liquid collections).....	2,245
Insecta (pinned specimens).....	5,500
Mollusca, collections.....	388
Fishes.....	196
Amphibia.....	59
Reptilia.....	15
Food collections.....	434

ENTOMOLOGICAL STUDIES.

It has been thus far the primary object of the entomological studies made by Mr. Hart to make us fully acquainted with each species in all its stages as a preliminary to investigations along other lines. To this end extensive search has been made of all varieties of situation in the waters of the Station field, the species at each location being listed at each visit and collections being also made. The regular typical localities represented by the substations have been further searched at regular intervals for two years. About five hundred lists and illustrative collections have thus been accumulated. The biological observations and breeding-cage experiments made during this time are recorded on some seven hundred note slips.

The Hymenoptera and a large part of the Diptera and Lepidoptera have been worked up, and reported upon in a paper on the entomology of the Illinois River and adjacent waters, published as Article VI. of Volume IV. of the Bulletin of the State Laboratory of Natural History. Since this publication much additional information concerning these groups has been acquired. Careful studies have been made on some of the smaller Diptera, on the water-beetles, and upon the Neuroptera, Thysanura, and Hydrachnidæ. The dragon-fly collections have been determined by Mr. J. C. Needham, formerly Instructor at Knox College, and by Mr. C. C. Adams, an assistant in the State Laboratory.

These entomological collections represent some 350 species of insects. Every effort has been made to identify, by breeding, eggs, larvæ, and pupæ of insects aquatic in any stage. About 275 hitherto undescribed forms have thus been obtained and immature stages of about 225 species have been accurately identified.

MOLLUSCAN COLLECTIONS AND DETERMINATIONS.

The Station collections of mollusks, made mostly by Mr. Hart, contain about 11,000 specimens, 600 of which are clams (Unionidæ). All this material except that most recently brought in has been examined and determined by various American specialists. About eighty-five names of aquatic or semi-aquatic mollusks have thus been obtained and their distribution and life history have received special attention. The Unionidæ have been studied with reference to characters derived from the entire animal and much interesting information has been accumulated concerning their relationships, life histories, and parasites.

FRESH WATER WORMS.

The greater part of the time of Professor Smith available for State Laboratory work has been devoted to a study of the oligochaete worms (earthworms and their allies) found in and about the Illinois River and other waters near Havana. Most of this work has necessarily been of a systematic character, although progress has been made along other lines. The importance of systematic work on this order is shown by the fact that with the exception of descriptions of two species published in Vol. III of the Bulletin of the State Laboratory,* almost nothing has been known of the representatives of the group in the Mississippi Valley and but little, indeed, for all the eastern part of the United States.

Collections have been made from all the regular substations and at various places in the bottom-lands and along the shores of the river to a point two miles south of Havana. Many of the worms obtained were studied while living, and for further study about seventy bottles of specimens have been prepared and preserved in alcohol or formaline. For a successful study of most of these worms serial sections are indispensable and thus far about four hundred microscopical slides of such sections have been made and used.

The work of identification is now nearly completed and probably nearly all of the different species occurring in the region are represented on our lists. Of the thirteen families of Oligochaeta recognized by Beddard, nine are represented at Havana by thirty species belonging to sixteen genera. Less than one half of these species occur in Europe and the remainder, with few exceptions, are known only from the United States. Two new genera and at least seven new species have thus far been found by us.

Numerous experiments have been made in rearing naidiform worms and considerable new information has thus been acquired concerning their asexual reproduction.

Identification and description of the planarian worms of the Station collections has been kindly undertaken for us by Professor W. M. Woodworth, of

Art. IV. "On the Anatomy and Histology of a New Earthworm (*Diplocardia communis*). gen. et sp. nov., by H. Garman; and Art. VII., "On an American Earthworm of the Family Phreoryctidæ," by S. A. Forbes.

Harvard University, to whom all our material has been sent, much of it alive. The work on these collections has all been done and Professor Woodworth's paper is nearly ready for publication.

STUDIES OF PROTOZOA AND ROTIFERA.

These minute animal forms of the Station fauna have been very patiently and thoroughly worked out from day to day for nearly two years by Mr. Adolph Hempel. As most of them could not be studied to advantage except in a living state, they have been determined as fast as collected. More than five hundred collections have thus been critically overhauled and annotated lists of species and descriptions of new forms have been prepared and either published or made ready for publication, in the Bulletin of the State Laboratory of Natural History. 102 species of Rotifera (three new) and 80 species of Protozoa (five new) have thus been listed from our situation by Mr. Hempel and several others have been identified by Dr. Kofoid in the course of his studies of the plankton since Mr. Hempel's work was suspended as a consequence of injury to his eyes. Among these later acquisitions was one of the most remarkable and important rotifers known to science, a species of the genus *Trochosphaera*, which is famous in the annals of zoölogy for the light which it throws upon the zoölogical relationships of the Rotifera at large. This genus, founded on a species discovered by Professor Semper in 1872 in pools in the rice fields of the Phillipine Islands, is now further represented only by collections made at Brisbane, Australia and in the Yangtse-Kiang, in China, and by the Illinois River specimens observed by Dr. Kofoid in the summer of 1896.

CHEMICAL DETERMINATIONS.

In a thorough going study of the œcological system of an aquatic situation, the chemical condition of the waters will necessarily be an important element, and the Station has consequently done what was possible to it in its present state to institute and encourage chemical studies of the waters from which its biological materials are collected. It is much to be desired that very frequent examinations should be made of the waters at all the typical substations with a view to tracing their chemical history at each throughout the day and under the changing conditions of season, stage of water, and the like. The gaseous contents of the waters are of special interest and importance to us, since they have probably most to do with the welfare of aquatic animals and plants. It has been impossible, however, during these first years to provide for more than the usual form of chemical examination of water as made for sanitary purposes and even this would have been impracticable if the chemical department of the University of Illinois had not responded generously to my request that such analyses be undertaken.

Beginning in May, 1894, collections of water from the river and from various other points in the Station field have been made at regular intervals by Station assistants and shipped to the Chemical Laboratory of the University, where they have been examined either by Professor A. W. Palmer or

by assistants working under his direction. Since the beginning of this work it has been merged in that of a Chemical Survey of the waters of the State established at the University in consequence of appropriations made by the State legislature to that end during the winter of 1895. One hundred and ninety-three analyses in all have now been completed and a report setting forth the comparative results will be published during the current year.

REPORTS AND PUBLICATIONS.

The final major product of our Station work must be in the form of published papers and reports, our material accumulations being of merely secondary interest and value and often of only temporary use. Necessarily, however, so soon after the organization of the work, it has not been possible to prepare and to publish papers of a sort adequately to represent the ideals of the Station management or to illustrate its final ends. Nevertheless, considerable contributions to science resulting from the investigations of the Station staff have already been printed or are now in press and the preparation of manuscript is going actively forward in several departments. Quite in accordance with our original expectation, visiting students who have availed themselves of the facilities of the Station have prepared or are now preparing papers embodying the results of their investigations, credit for which must belong in part to our establishment, without which they would not have been written.

The principal contributions now in print are papers by Mr. Hart, Mr. Hempel, and Professor Smith. The first of these is an article by Mr. Hart on the entomology of the Illinois River and adjacent waters, filling one hundred and twenty-five pages of our Laboratory Bulletin and illustrated by fifteen half-tone plates. Professor Smith's additions to a knowledge of our oligochaete worms have appeared as two papers of the Laboratory Bulletin, describing four new species and a new genus of these animals, with a large amount of anatomical and histological detail. We have also printed an article by Mr. W. H. Ashmead, of the United States National Museum, on parasitic Hymenoptera bred from aquatic insects at Havana, containing descriptions of three new species. Four new species of Protozoa and three of Rotifera from Station situations have been described by Mr. Hempel in an article of the State Laboratory Bulletin, accompanied by five plates of illustrative figures.

We have now going through the press a third paper by Professor Smith, containing a description of a new genus and two new species of oligochaete worms from Havana, and of one from Florida, together with a description of the reproductive organs of *Pristina*, upon which subject nothing has heretofore been known. This article will be accompanied by four plates. A paper on the Ostracoda of North America, by Mr. R. W. Sharpe, a graduate student of the University, is also in press. This article has been made to include the product of a careful examination of the collections made in this group from the opening of the Station to the midsummer of 1896. It is accompanied by ten plates.

Mr. Hempel's observations on the Protozoa and the Rotifera of the Station, accumulated during two years' continuous study, are in hand in the form of

a completed manuscript, accompanied by thirty folded sheets setting forth in tabular form the distribution of the various species at each substation and also throughout the Station field for the different months of the year. This report was finished last September and will be printed without delay.

Dr. Kofoed has lately filed a report, which is about to go to press, on methods and apparatus in use in plankton work at the Station, accompanied by seven illustrative plates. He has in hand six other papers, which will doubtless be ready for publication before the end of the current fiscal year. These will include reports on the local distribution of the plankton in the Illinois River and its adjacent waters, on the sources of error in the plankton method, on the plankton of the river during the years 1894, 1895, and 1896, on the plankton of Phelps Lake,—a body of water of the ephemeral type,—an article on *Trochosphæra*, and one on *Cotylaspis insigne*—a remarkable parasite of the river clams.

Professor Smith has under way a general report on our oligochaete collections, to consist of about fifty pages of text with several plates. This report will contain a synoptic key and illustrated descriptions of species for use in identifying forms occurring in the State.

Mr. Hart, Station Entomologist, and Mr. J. G. Needham are working conjointly upon a report on the dragon-flies of the Station waters and their vicinity and a list of the mollusks with biographical and œcological notes is in course of preparation by Mr. Hart.

Two senior students of the zoölogical department of the University, Mr. E. B. Forbes and Mr. F. W. Schacht, are engaged in thesis investigations, under the personal supervision of the Director of the Station, which will result in the preparation and publication of papers on entomostracan groups, one the Cyclopidae, the other the Centropagidae, of North America, including of course the Station collections.

I have myself undertaken to prepare, and have nearly finished, a comprehensive article on the Crustacea of the Biological Station field, with analytical synopses of all the groups and illustrative figures for the use of the student of our aquatic fauna.

A paper on the planarian worms found at Havana is now reported as practically ready for the press in the hands of Dr. W. M. Woodworth, of Harvard University. Articles in course of preparation by visiting investigators are "The Mycetozoa collected near Havana, Illinois, during the summer of 1896," by H. C. Beardslee, of University School, Cleveland, Ohio, and "Statistical Record of the Trematoda Parasitic in the Unionidae," by Professor H. M. Kelly, of Cornell College, Iowa.

The excellent work done by the Station Artist, Miss Lydia M. Hart, in illustration of nearly all the papers of the foregoing list, is deserving of particular mention. One hundred and three drawings have been made by her of new or otherwise interesting animal forms, besides several drawings of pieces of apparatus and other features of the equipment.

General mention may also be made in this connection of the publication and widespread distribution of a preliminary report upon the Station* illustrated by seventeen plates of the situation and surroundings, and of a small illustrated pamphlet descriptive of the Station and its work, inviting advanced students and other competent investigators to share its privileges during the vacation months of 1896.

SUMMER OPENING OF THE STATION.

With the launching and equipment of the cabin-boat it first became possible for us to offer the facilities of the Station to students outside our own official group. Anticipating this opportunity, a pamphlet of twenty-four pages, containing twelve half-tone plates, was distributed in the fall of 1895, describing the Station and its surroundings, its equipment, its plan of operations, and its program for the season, and making the following offering.

"The establishment and recent equipment of the Biological Station of the University of Illinois will afford a unique opportunity to a limited number of competent students to become acquainted with the plant and animal forms and with the system of life of a continental river and its dependent waters, and with comprehensive methods and modern apparatus of investigation in aquatic biology. This opportunity, it is believed, will be valued not only by interior students who would like to enlarge their personal knowledge of the aquatic life of their own territory, but also by investigators of experience in other fields who may wish to extend their studies, for the sake of comparison, into a department of American biology hitherto practically unexplored."

"For these reasons, and notwithstanding the fact that this Station was established especially as a means of research by its own staff, it has been decided to open it for the months of June, July, and August to biological investigators and to students of some experience in zoological or botanical work. The present accommodations are sufficient for only sixteen persons additional to the Station force. Applications for admission must consequently be made in advance and at as early a day as practicable, with precise specification of the period for which the applicant wishes to occupy a table in the Station Laboratory."

* * * * *

"Applications for admission to the Station will be entertained this first year only from independent investigators and from students of biology who have had sufficient experience to render systematic instruction and continuous supervision unnecessary. Other things being equal, instructors in biological science in colleges and public high schools will be given the preference."

"Tables on the laboratory boat or in the rooms on shore, and other general laboratory facilities, will be provided for those whose applications are accepted; ordinary microscopic reagents will be supplied; and access will be given to the biological library of the Station. Books will also be loaned, as needed, from the library of the State Laboratory of Natural History and

* See *Bien. Rep. Direc. Ill. State Lab. Nat. Hist.*, 1893-94, p. 14.

from that of the University of Illinois. Occupants of the laboratory will be expected to furnish their own microscopes or to pay a small fee for the use of those of the University. They are advised to bring also any collecting apparatus in their possession, as the laboratory equipment may otherwise be insufficient for all wishing to use it. Students must furnish their own alcohol for private collections, and especially expensive reagents—such as osmic acid or platinum-chloride.”

“Although the Station is established and maintained primarily for a study of life histories, interactions of organisms, and reactions with the environment, no restriction will be placed upon the lines of zoölogical or botanical work to be pursued by those in attendance. In making application, however, the candidate should describe the nature of the study he wishes to pursue, and should also indicate the kind and amount of preparation for such work he may already have had. Applications will not, as a rule, be considered later than a fortnight previous to the time at which a table is desired, and no formal permission will be given for a stay of less than two weeks. Within these limitations visitors may come and go at any time within the months of June, July and August.”

“Reports on the Protozoa, rotifers, oligochaete worms, Cladocera, and insects of the Station, and perhaps on one or two other groups also, will be in print by the 1st of June, and will be furnished free of charge to those desiring to make studies in these groups.* These papers will contain analytical keys, descriptions of species, genera, etc., or references to descriptive literature accessible at the Station, together with much biological and œcological detail.”

“While no provision is made for formal instruction, it is expected that the membership of the Station will be organized as a biological club to hold stated meetings for conference, discussion, and occasional lectures by the Station force or by visiting specialists.”

“An incidental fee of \$5 a month will be charged to each participant.”

The privileges thus tendered were finally accepted by seventeen persons, who were in attendance during the summer for periods ranging from three to ten weeks. Although the number of tables available for outside use was only fifteen, not all of this group were present at a time, and the floating laboratory afforded sufficient accommodations for all who came. The states and institutions represented and the subjects to which special attention was given are shown by the following list:

C. C. Adams, B. S., Assistant in Biology, Wesleyan University, Bloomington, Illinois. Dragon-flies.

H. C. Beardslee, A. B., Instructor in Science, University School, Cleveland, Ohio. Fleshy fungi, Myxomycetes, and aquatic flora.

Miss L. L. Conover, B. S., Teacher of Botany, High School, Detroit, Michigan. Algæ and Myxomycetes.

* It proved impossible to carry out the intention expressed in this paragraph, but the unlimited use of the library facilities of the State Laboratory of Natural History made fully good to visitors the substance of this offering.

Charles Fordyce, Principal of the Normal Department, Biology, Nebraska Wesleyan University, University Place, Nebraska. Fresh-water Algæ and general biology.

H. A. Fraser, B. S., Teacher of Biology, High School, Joliet, Illinois. Fresh-water sponges and general biology.

W. K. Hill, A. B., Superintendent of Schools, Carthage, Illinois. Fresh-water Algæ.

G. W. Horton, Superintendent of Schools, Dwight, Illinois. Rhizopoda and general biology.

H. M. Kelly, A. M., Professor of Biology, Cornell College, Mt. Vernon, Iowa. Trematoda parasitic in clams.

J. G. Needham, M. S., Instructor in Zoölogy, Knox College, Galesburg, Illinois. Life histories of dragon-flies.

C. S. Oglevee, B. S., Instructor in Zoölogy and Botany, Lincoln University, Lincoln, Illinois. Protozoa and general biology.

C. E. Phillips, Millington, Illinois. Student at Eureka College, Eureka, Illinois. General biology.

Mrs. W. S. Pierce, Teacher of Science, High School, Havana, Illinois. General biology.

Maurice Ricker, B. S., Teacher of Chemistry and Biology, High School, Burlington, Iowa. Hydrachnidæ and general biology.

L. S. Ross, M. S., Professor of Biology and Geology, Drake University, Des Moines, Iowa. Cladocera of Iowa and Manitoba.

F. W. Schacht (U. of I., '97), Moline, Illinois. The Centropagidæ of the locality in connection with thesis investigation.

R. W. Sharpe, B. S., Teacher of Biology, High School, Danville, Illinois. Ostracoda.

C. A. Whiting, Sc. D., Professor of Biology, University of Utah, Salt Lake City, Utah. General biology.

FINANCIAL RESOURCES AND EXPENDITURES.

The entire sum available for the equipment of the Station and its maintenance for three years and three months has been \$10,300, \$1,800 of which was appropriated by the Trustees of the University March 13, 1894, for the commencement of the work, and the remainder of which is derived from legislative appropriation made in June, 1895. Two thousand five hundred dollars of this latter appropriation was for building and equipment and \$6,000 for running expenses for two years. The equipment fund has been expended in the purchase and modification of the Station launch "Illini," in building, furnishing, and equipping the floating laboratory and in providing various minor items of apparatus and furniture.

The floating laboratory or cabin-boat cost \$1,573 furnished and equipped, the contract price for construction being \$1,255. Five thousand five hundred and six dollars had been expended September 30, 1896, on account of salaries and general expenses of the Station, a balance of \$1,394 remaining in hand to the credit of the appropriation. The salaries for this period of thirty months have been \$4,218,—an average of about \$140 per month,—and the general expenses of the work have been \$2,187—approximately \$73 per month.

PRESENT NEEDS AND FUTURE DEVELOPMENT.

The principal present needs of the work, apart from a fund sufficient for its maintenance on existing lines, are (1) more elaborate provision for chemical investigations, (2) a salary fund sufficient to enable me to add an experienced botanist to our present staff, (3) a site of three or four acres near the foot of Quiver Lake, and (4) provision for two principal buildings on shore and for a small system of permanent ponds with a pumping equipment for their maintenance.

The necessary chemical work will undoubtedly be provided for by the Chemical Survey of the waters of the State if the funds available for that survey are made sufficient to enable the University chemists to meet our wishes in this respect. As already said under another head in this report, chemical analyses are a matter of the first importance to the whole investigation we have undertaken. They will have a very great incidental value also outside our own field because of their bearing upon questions of public health as affected by pollution of the waters of the Illinois River by sewage and other waste from the towns above, and ultimately from Chicago by way of the drainage canal.

A knowledge of the plant life of the river is scarcely second in importance to that of its animal life; a fact which has been evident to me from the beginning, but which, nevertheless, I have been compelled largely to ignore because of lack of funds to provide for continuous botanical investigation. Several competent zoölogists were already in our employ as assistants in the State Laboratory of Natural History, and zoölogical investigation could consequently be provided for with little difficulty and at a relatively small expense. Furthermore, the smaller animal forms—the rotifers and the Protozoa—can be successfully studied as a whole only in the living state, while microscopic plants are capable of preservation in condition to make their subsequent determination practicable. Our plant collections can consequently still be worked up by a botanist having an expert knowledge of aquatic forms. It is very much to be desired that another year may not be allowed to pass without provision for this indispensable part of our general subject, without which, indeed, final conclusions concerning the œcology and economics of our aquatic biology cannot possibly be reached.

The efficiency of our corps of workers and the quantity of the results of their work would be very greatly increased if provision were made for their continuous maintenance on Quiver Lake. Our daily trips to and from the town proved very wasteful of time and opportunity, and have added greatly to the expense of running the Station launch. Furthermore, notwithstanding the great usefulness of our floating laboratory, it is in some respects insufficient for the more advanced stages of our work, and should be supplemented by a laboratory building in the immediate neighborhood. Experimental researches will presently require a larger equipment than that now at our disposal in the jars and small aquaria to which we are at present confined.

Finally, if the Station is to be utilized to the fullest extent as a means of instruction to teachers in the public schools, permanent provision for this work must certainly be made.

These various needs can be met by the purchase of a small tract of land now lying practically waste, by the erection of a small building on the bank of Quiver Lake which shall combine additional facilities for laboratory investigation with living quarters for the Station staff, by the excavation of ponds on the Station grounds and the construction of a water tank and pump, and by the building of a large pavilion, with some connected rooms, for mid-summer work by visiting students.

Concerning the immediate future of the work, I beg to say that it is my present wish and intention, if the Station is maintained on a scale and under conditions to make it possible, to extend its work especially along three principal lines. The preliminary systematic survey having been now largely completed, I hope next to select specific problems for solution by experimental methods, working towards definite œcological results of scientific value. Studies of the lower forms of aquatic life in our situation are now so far advanced as to make it profitable to bring into our scheme of regular operations the fishes of these waters. A particularly thorough, continuous, and comprehensive study of them should be made from various points of view, in the hope especially of helping the fish-culturist to more intelligent methods and to more certain and permanent results.

Although the Station was founded primarily for investigation and its expenditures up to the present time have all been made directly to that end, it is very apparent that it has a highly important work to perform in the interests of public education. I hope to occupy fully and at once this broad field of usefulness which now lies so plainly open before us, not only by continuing and enlarging our offerings to advanced students and to investigating naturalists, but especially by providing all needed facilities and instruction in field biology and in special pedagogical methods to present and prospective teachers of the natural history subjects in all grades of the public school. As a first step to this object, I have already submitted to you a plan for a summer school of field biology to be opened during the vacation season of next year. This work should, I do not doubt, become a permanent and prominent feature of the Station operations.

I ought not to close this general review and presentation of the affairs of the Biological Station without calling your attention to the cordial and appreciative manner in which our enterprise has been received by expert judges of high rank in this country and abroad. Important articles on its work have appeared in several of the leading scientific journals of Europe and America, and our official correspondence also contains many expressions of warm interest in our success from eminent men in various parts of the world.

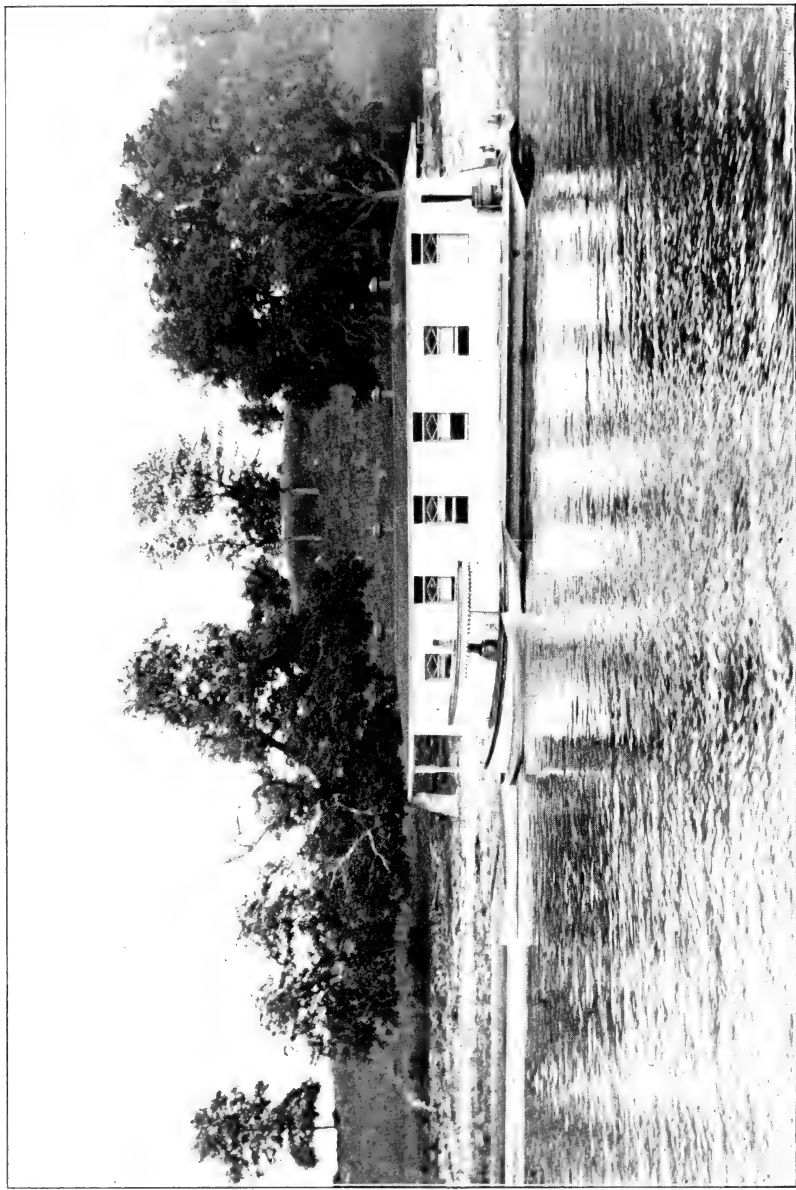
It gives me further pleasure to express to you my high appreciation of the capable, energetic, and successful work of my associates on the Station staff. Neither the broiling heat of the July sun nor the midwinter's cold have been able to interrupt or even to delay the regular progress of the very laborious

and exacting routine of their operations; and the steady strain of long months of confining work at the microscope has been taken by them with the patient enthusiasm of the trained investigator at work in a fruitful field. The contagion of the example of this little group of indefatigable naturalists is clearly affecting the life of related departments of the University, and it must in time make itself sensibly felt throughout the state and the country in the advancement of biological science and in the improvement of our methods of biological instruction.

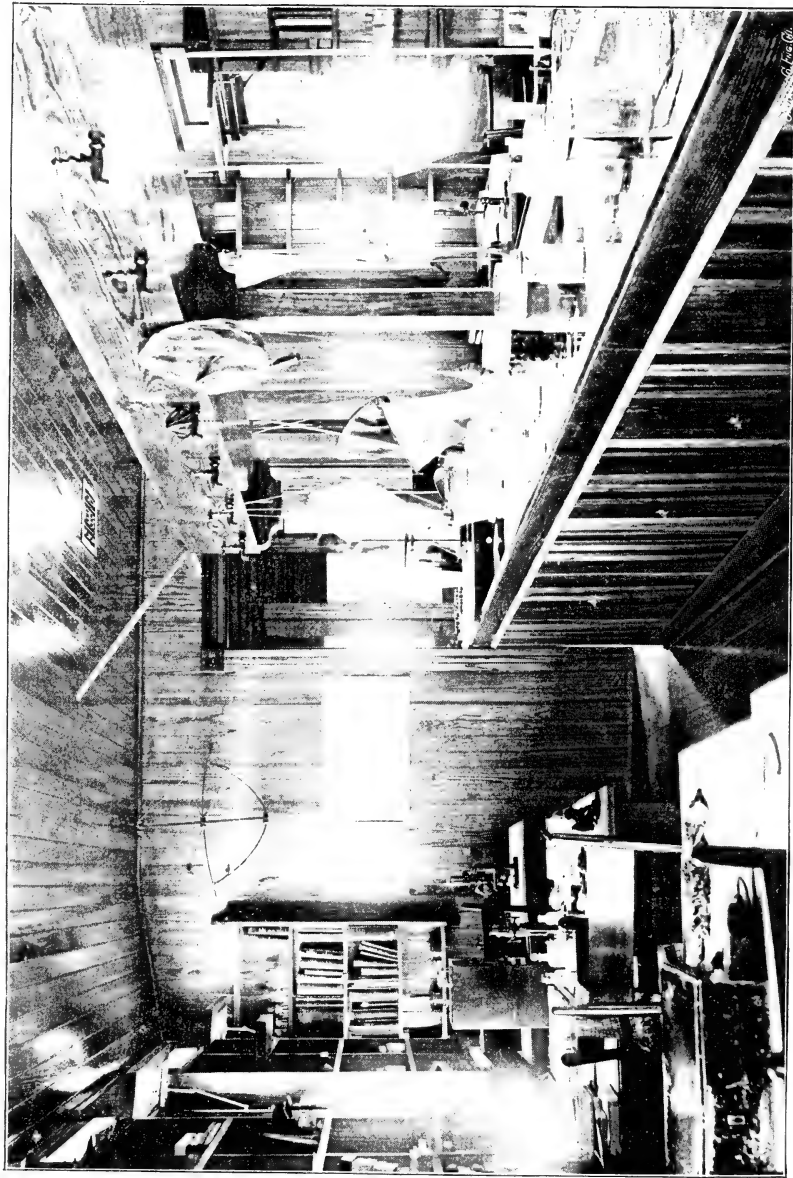
Respectfully submitted.

S. A. FORBES,
Director.

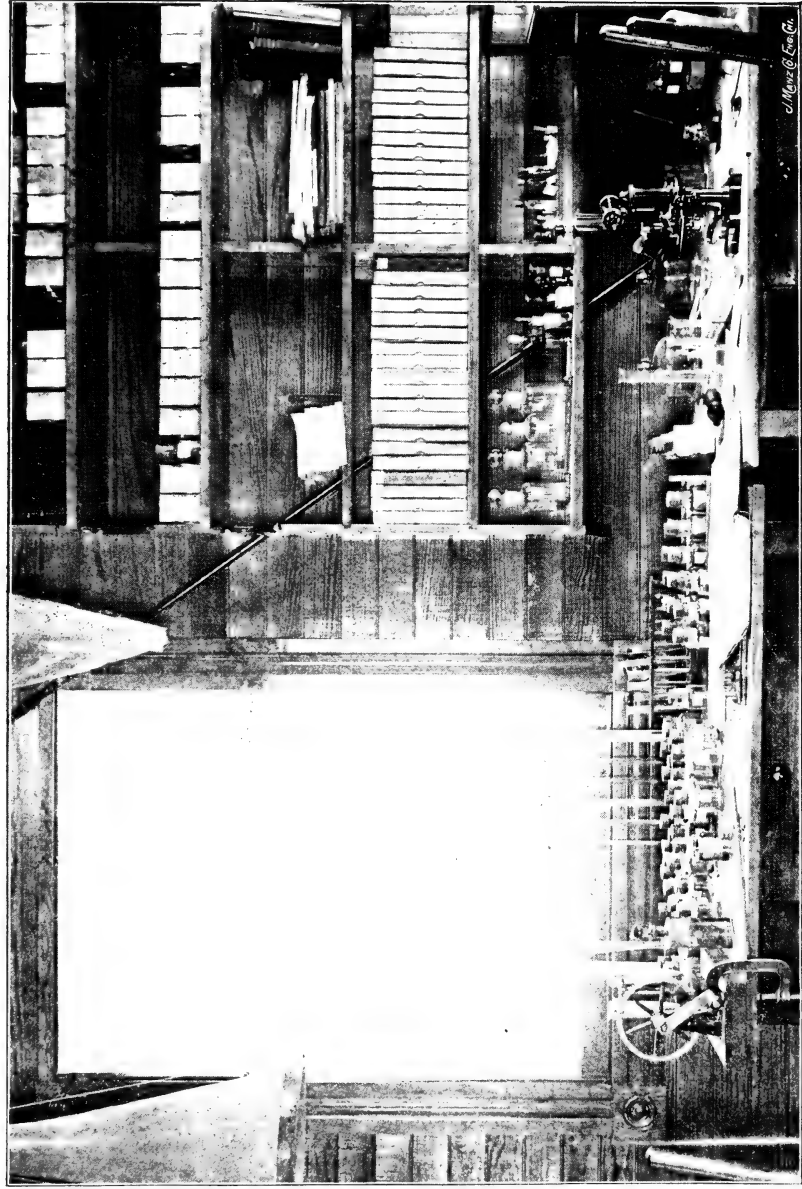
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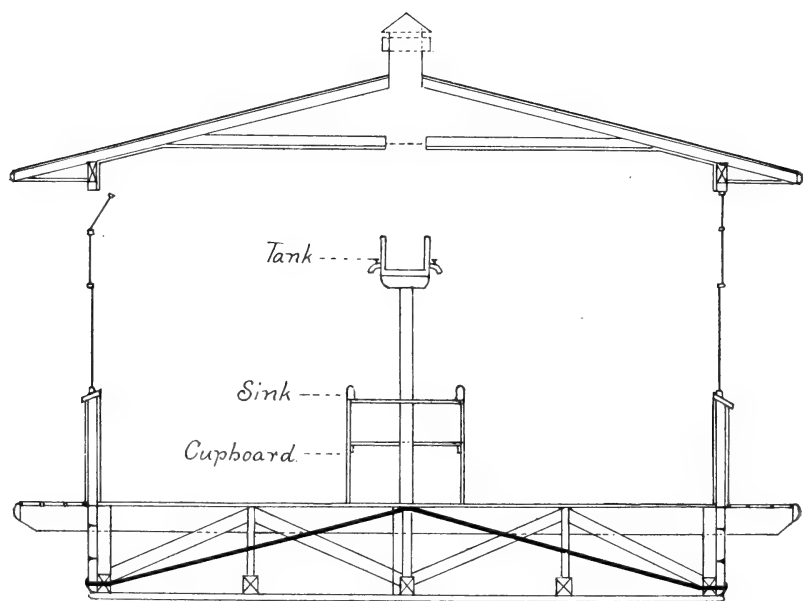
FIELD HEADQUARTERS, FOOT OF QUIVER LAKE.



MAIN ROOM OF LABORATORY BOAT.

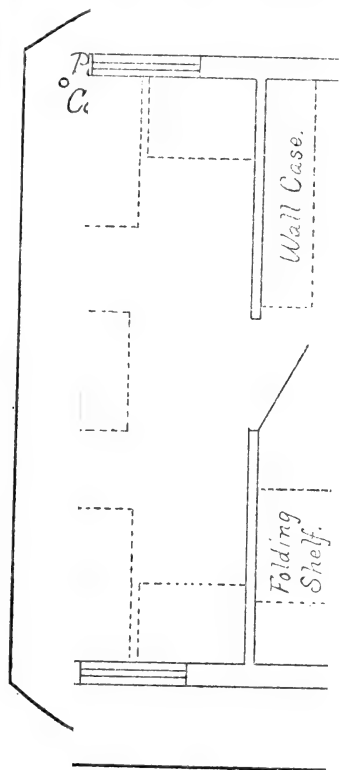


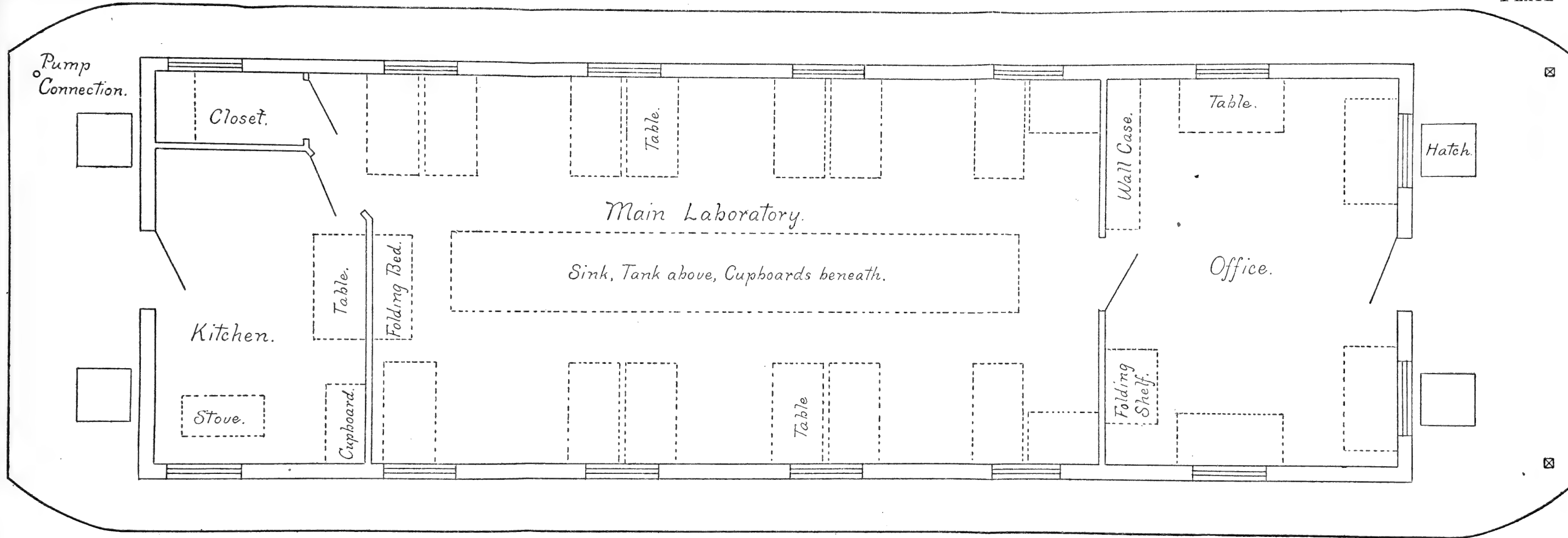
STAFF ROOM IN LABORATORY BOAT.



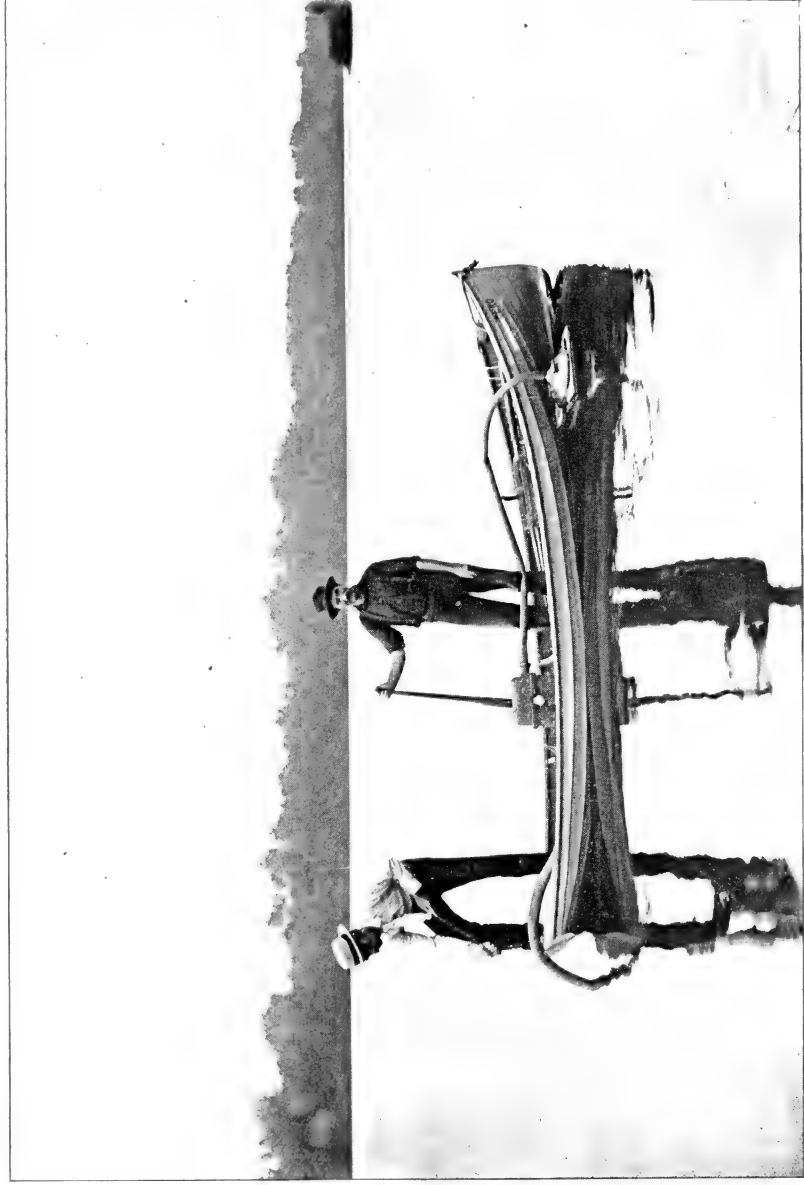
Cross Section of Cabin.

BIOLO

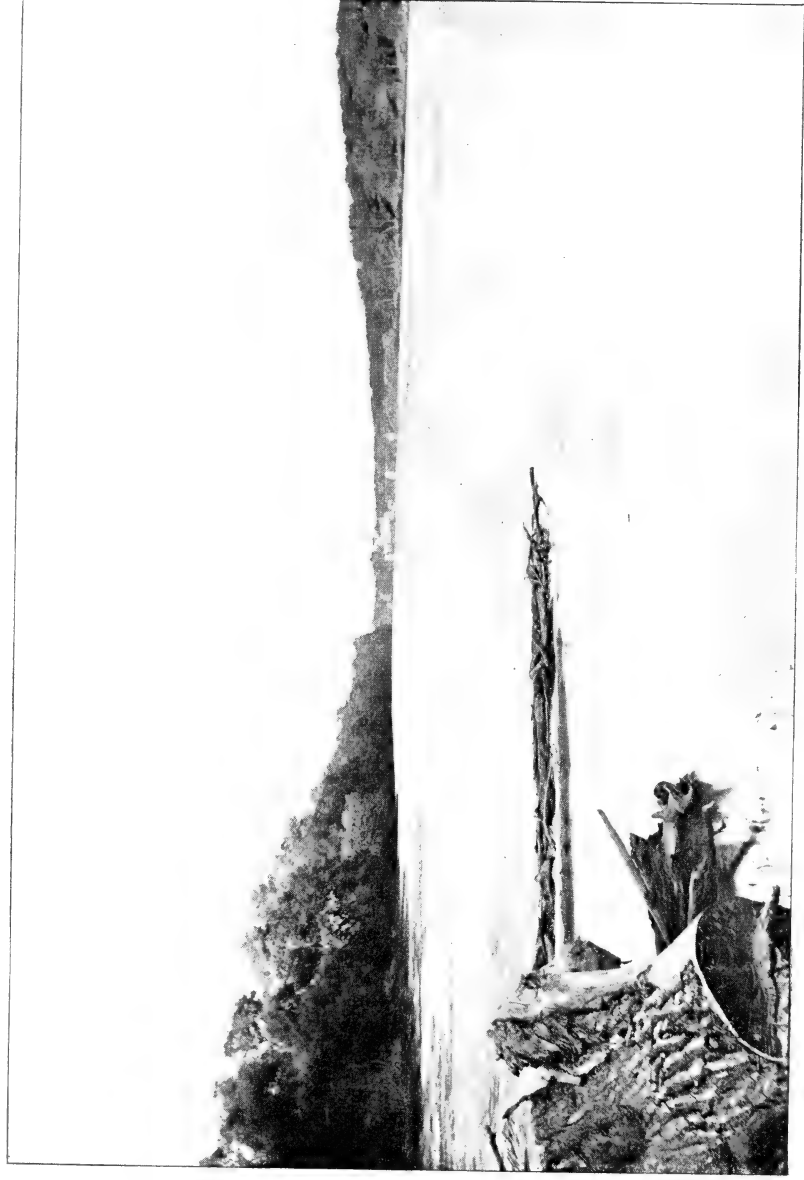




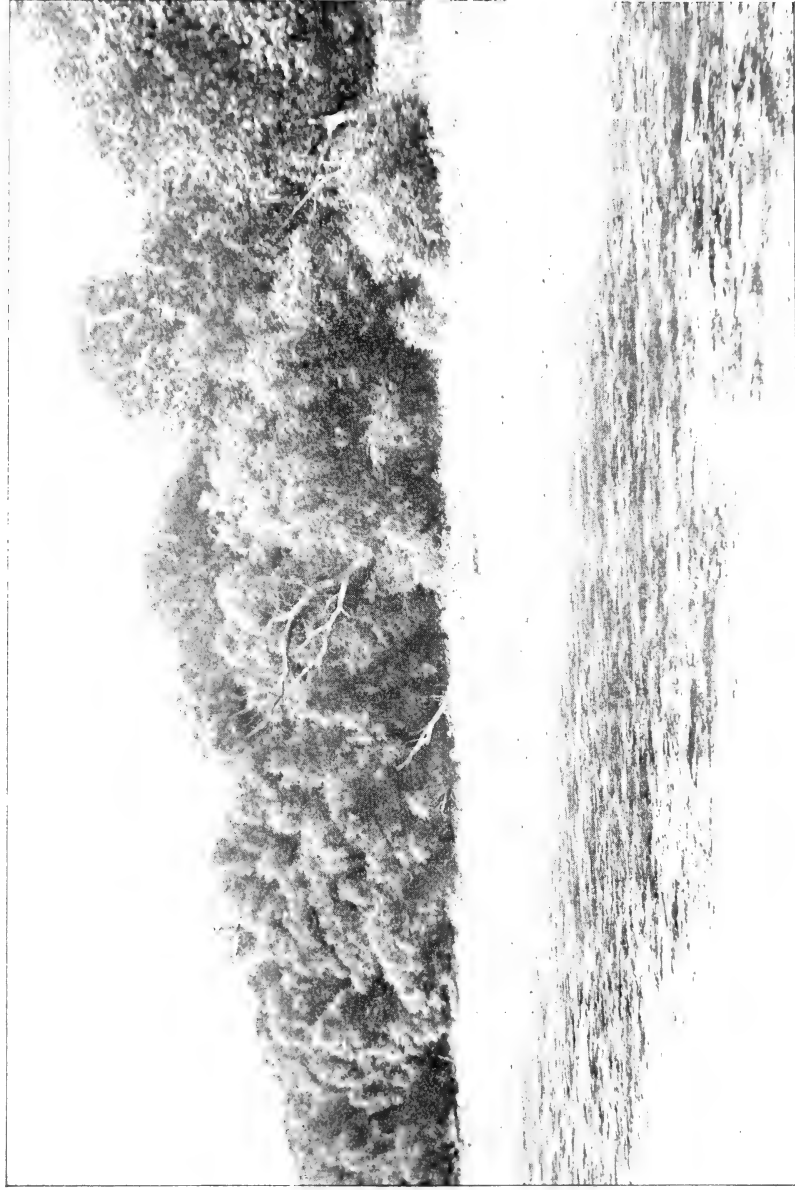
Plan of Cabin.

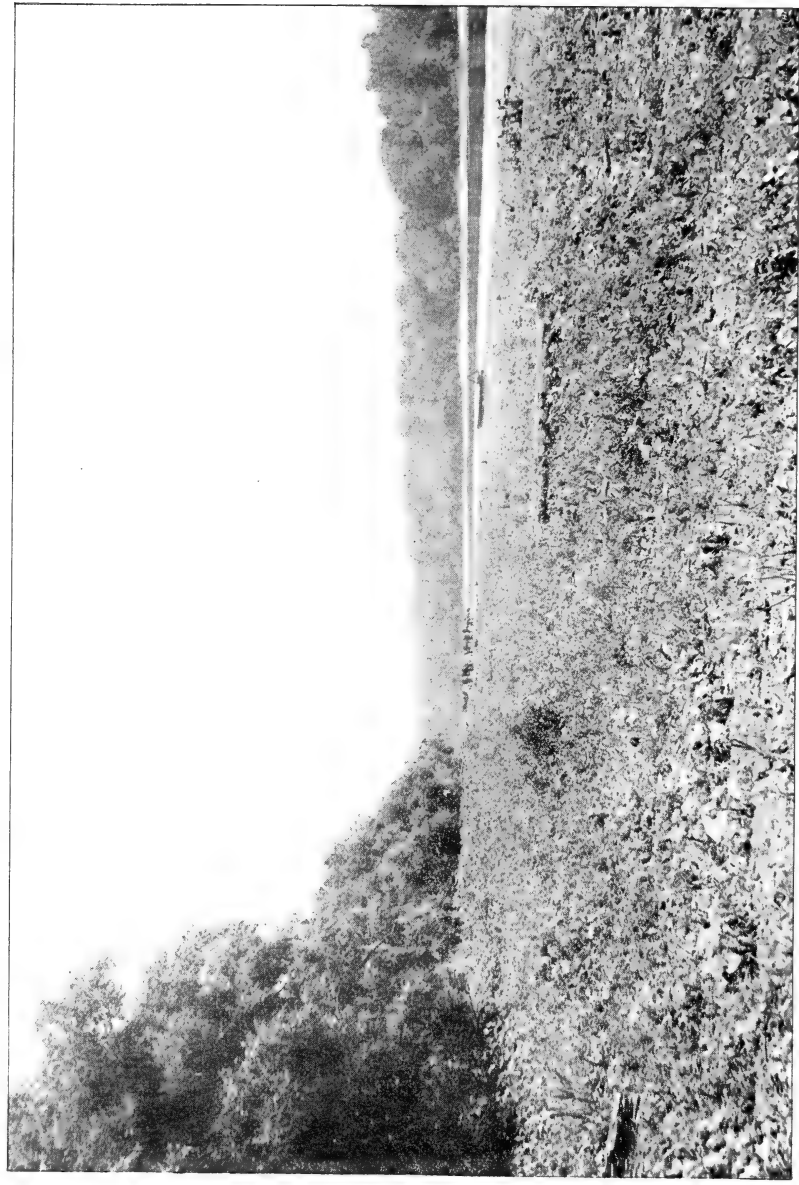


TAKING A PUMP PLANKTON, ILLINOIS RIVER.

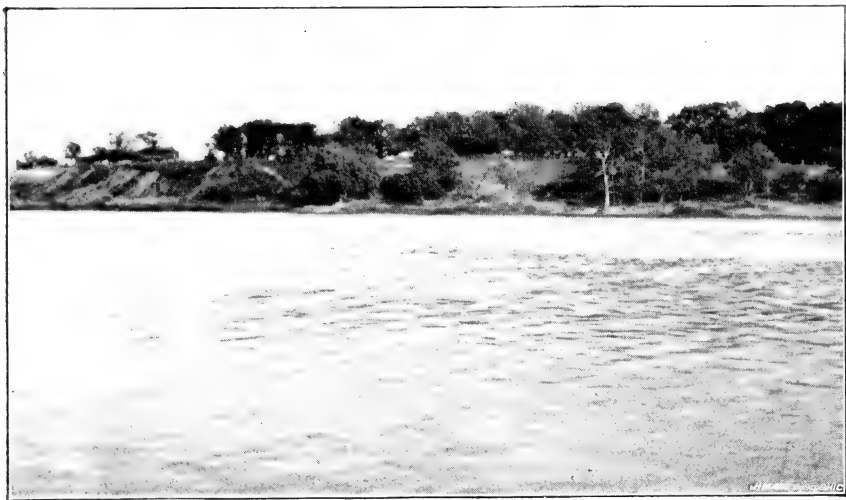


ILLINOIS RIVER, LOOKING NORTH TOWARDS HAVANA.





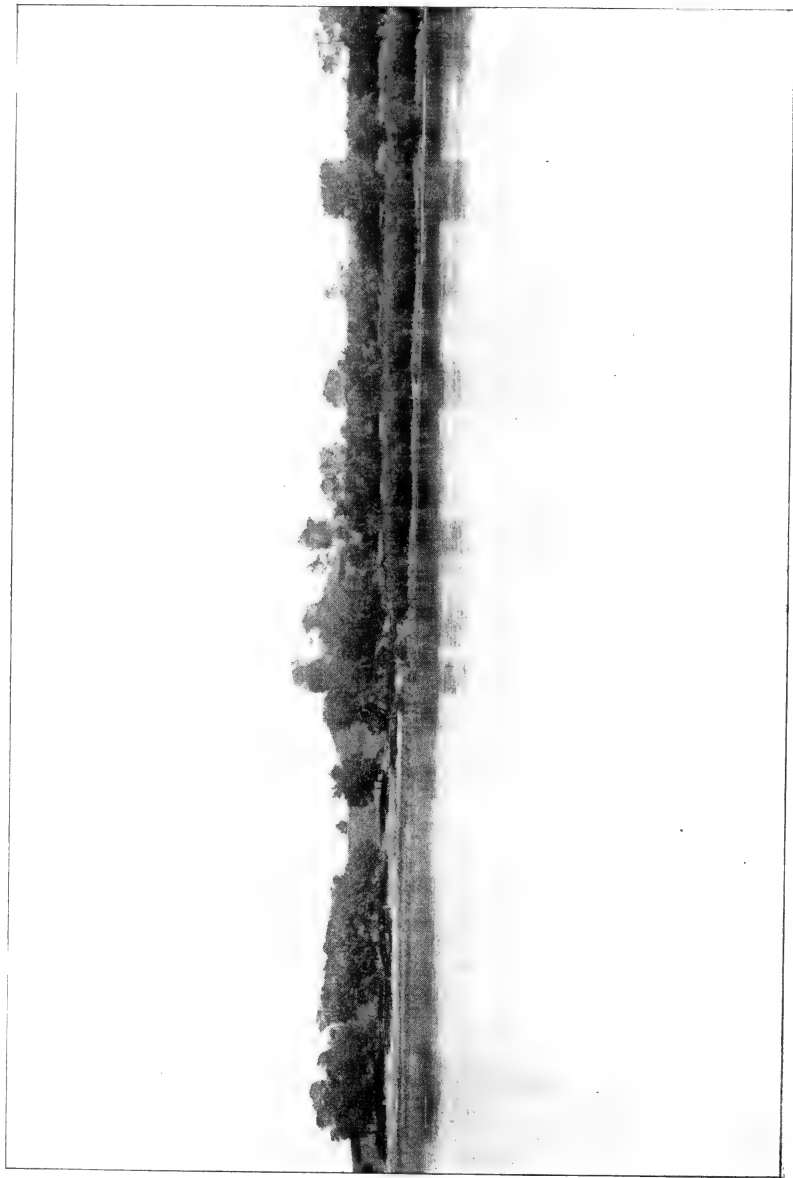
EXPOSED SLOPE OF WEST RIVER BANK AT LOW WATER.



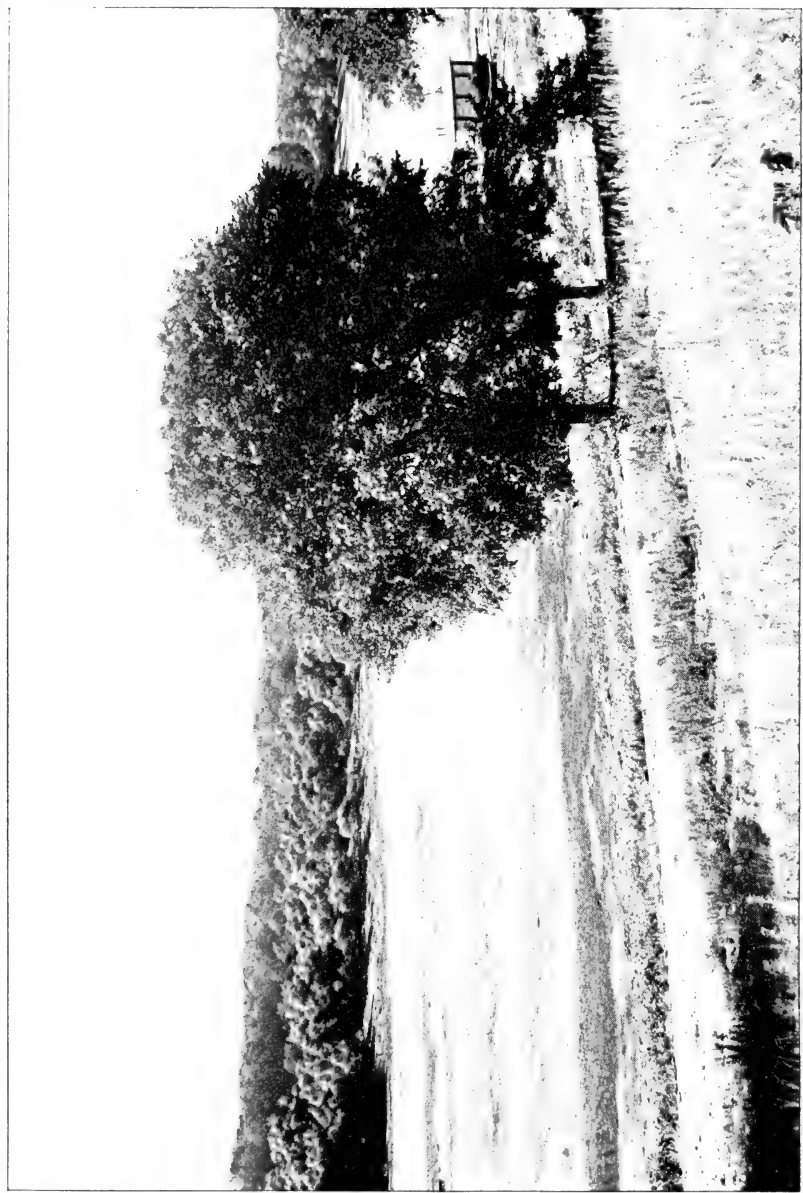
EAST BANK OF ILLINOIS RIVER. SUBSTATION H.



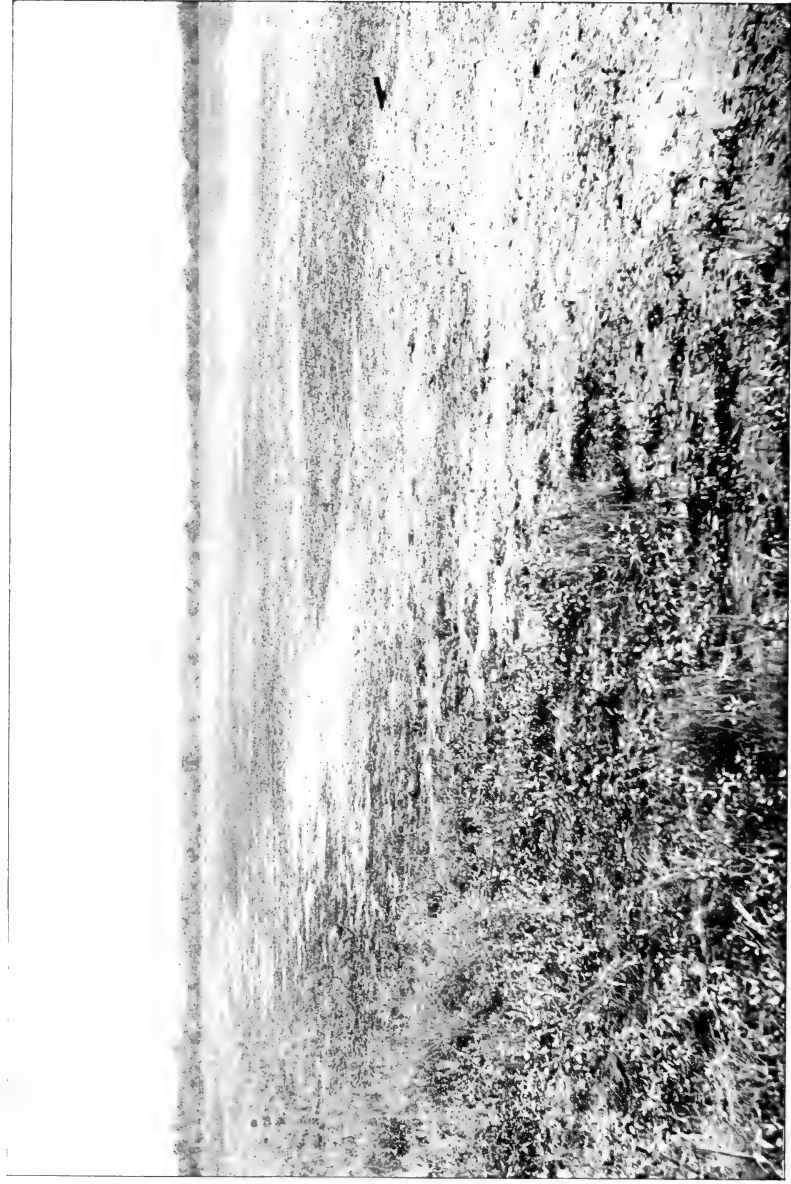
STATION LAUNCH, IN QUIVER LAKE.



EAST BANK OF QUIVER LAKE. TWIN MOUNDS.



QUIVER LAKE, SUBSTATION C. MIDSUMMER.



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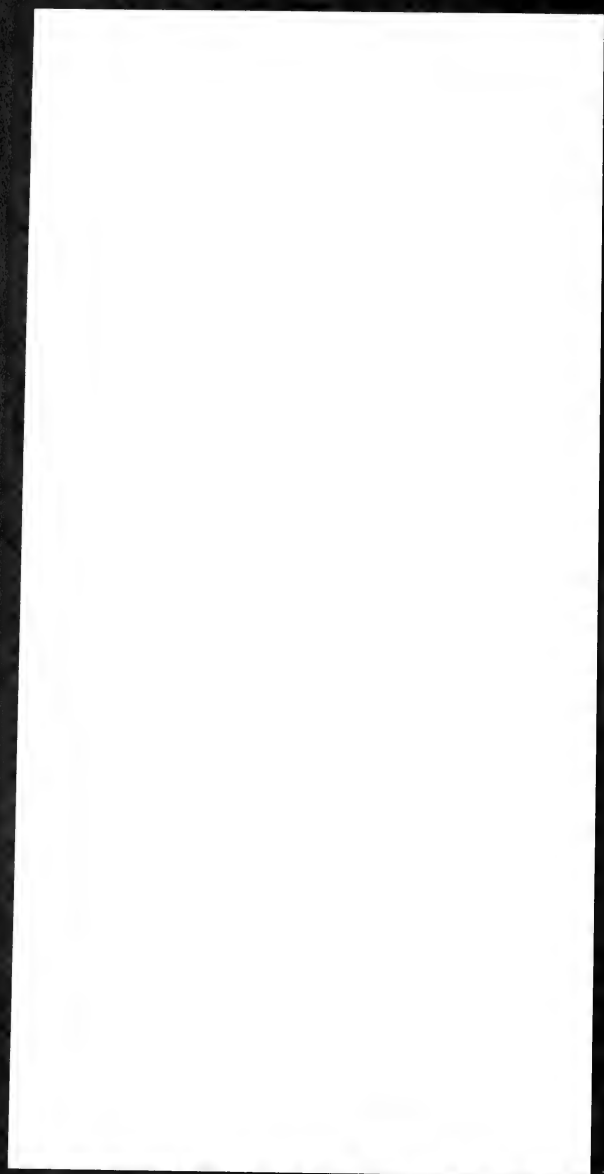
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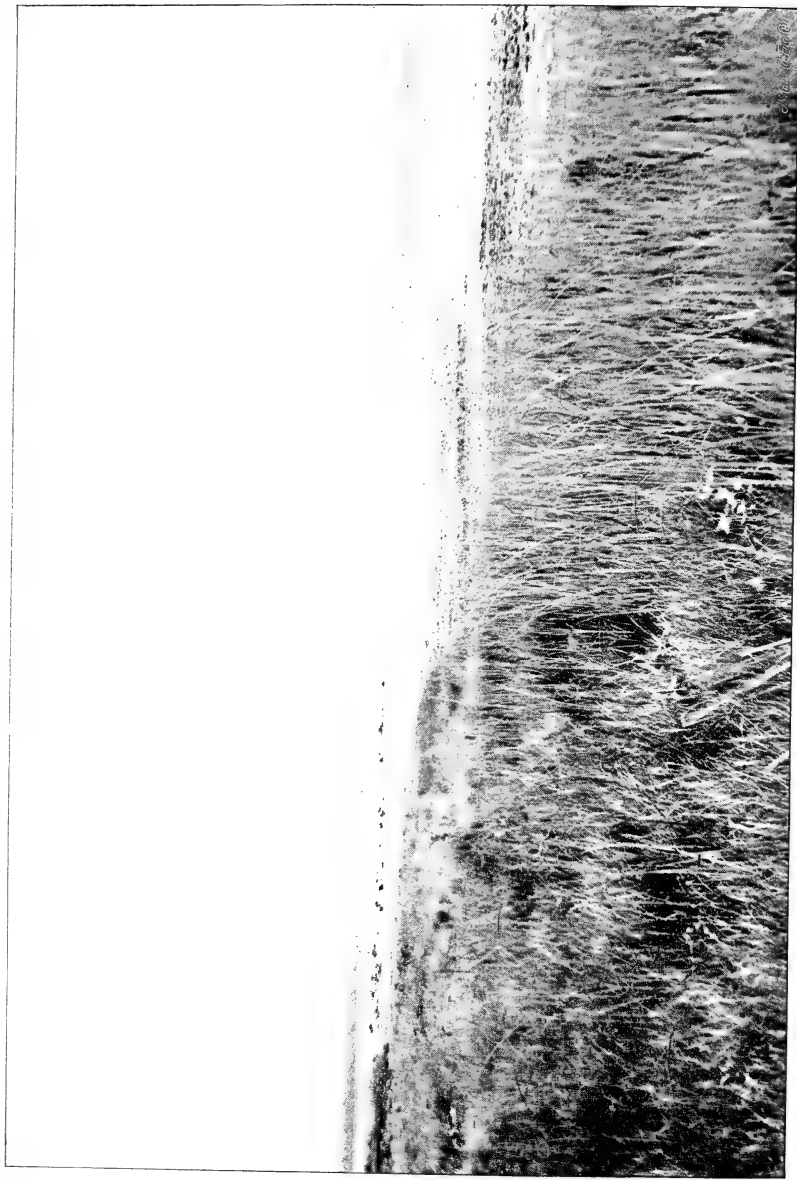
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FLAG LAKE, LOOKING NORTH.



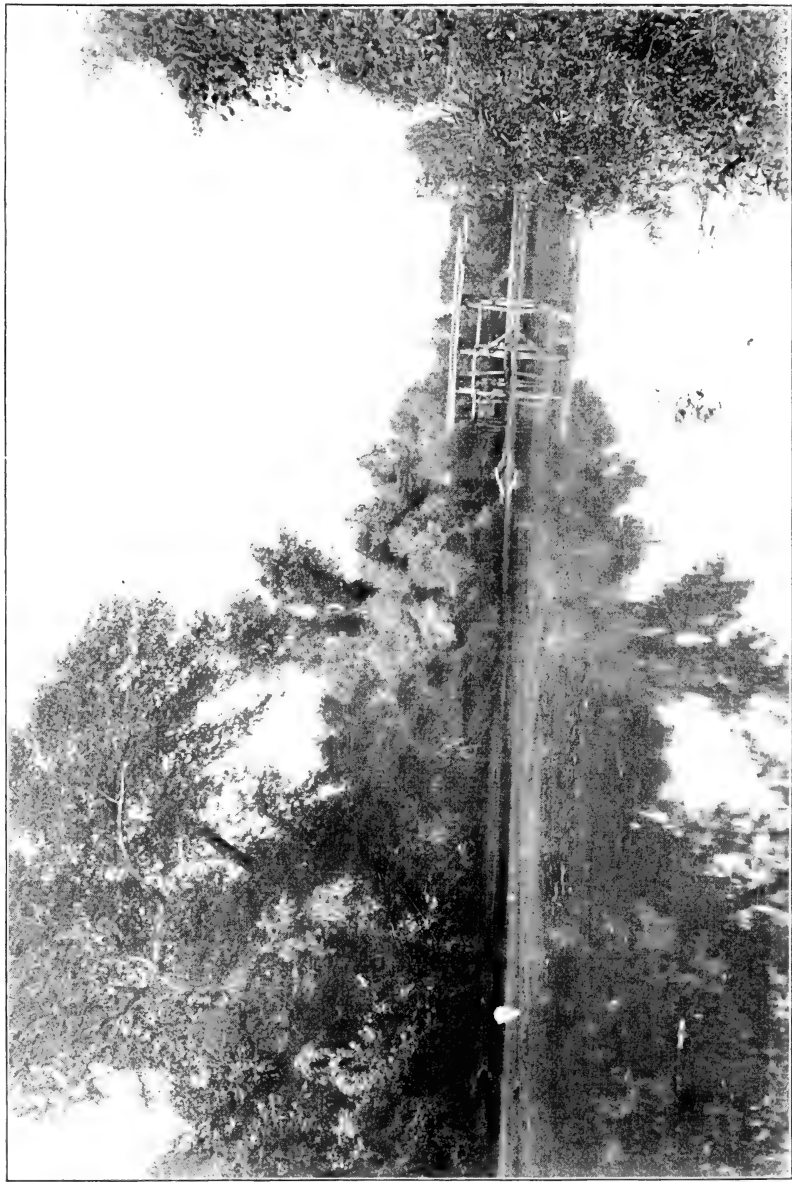
THOMPSON'S LAKE, LOOKING SOUTH.



DEEP SLOUGH, NEAR MATANZAS LAKE.



QUIVER CREEK, ONE MILE FROM LAKE.



SPOON RIVER, NEAR ITS MOUTH.



BOTTOM-LANDS AT HIGH WATER.



BOTTOM-LAND FOREST, NEAR MATANZAS LAKE.

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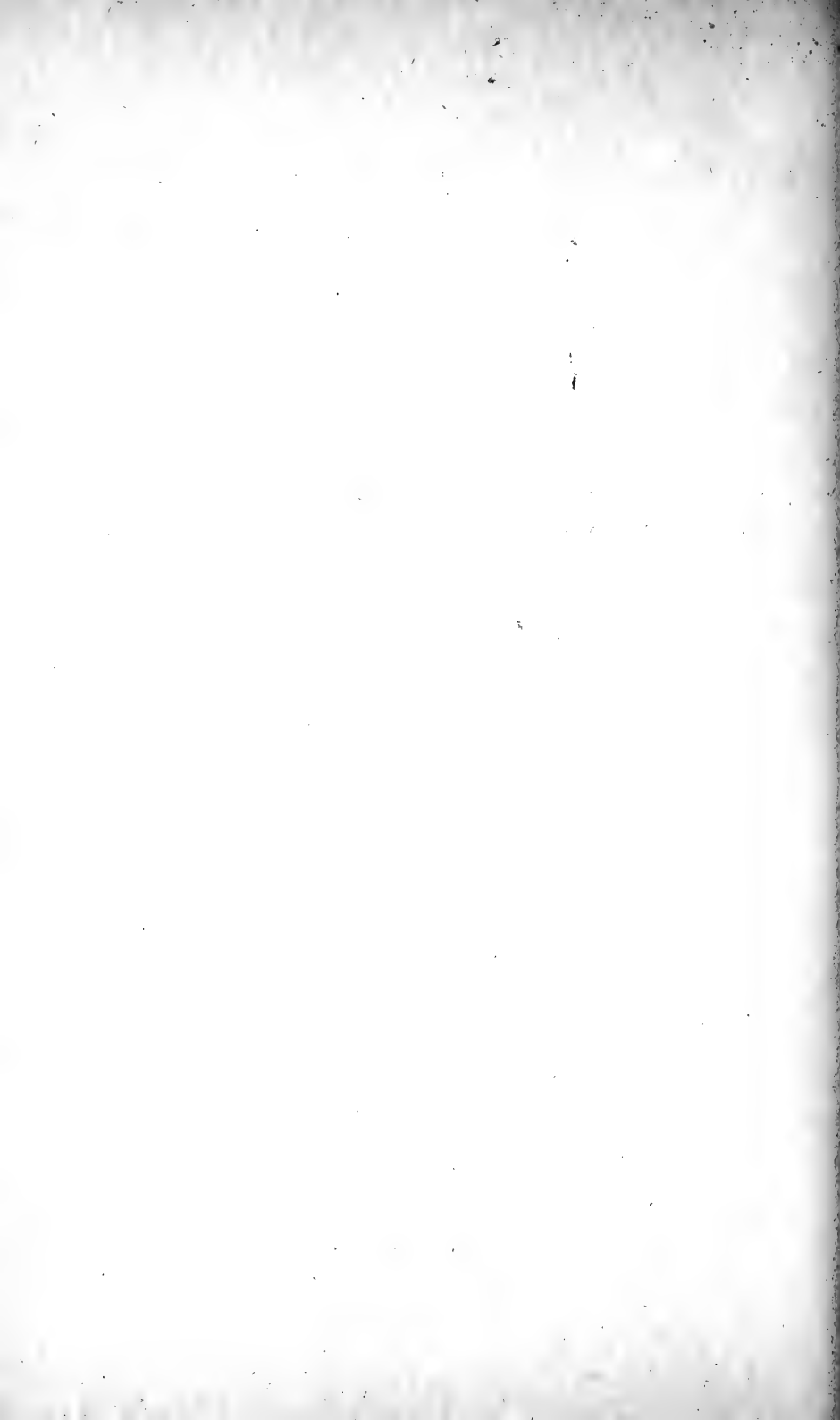
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BIENNIAL REPORT

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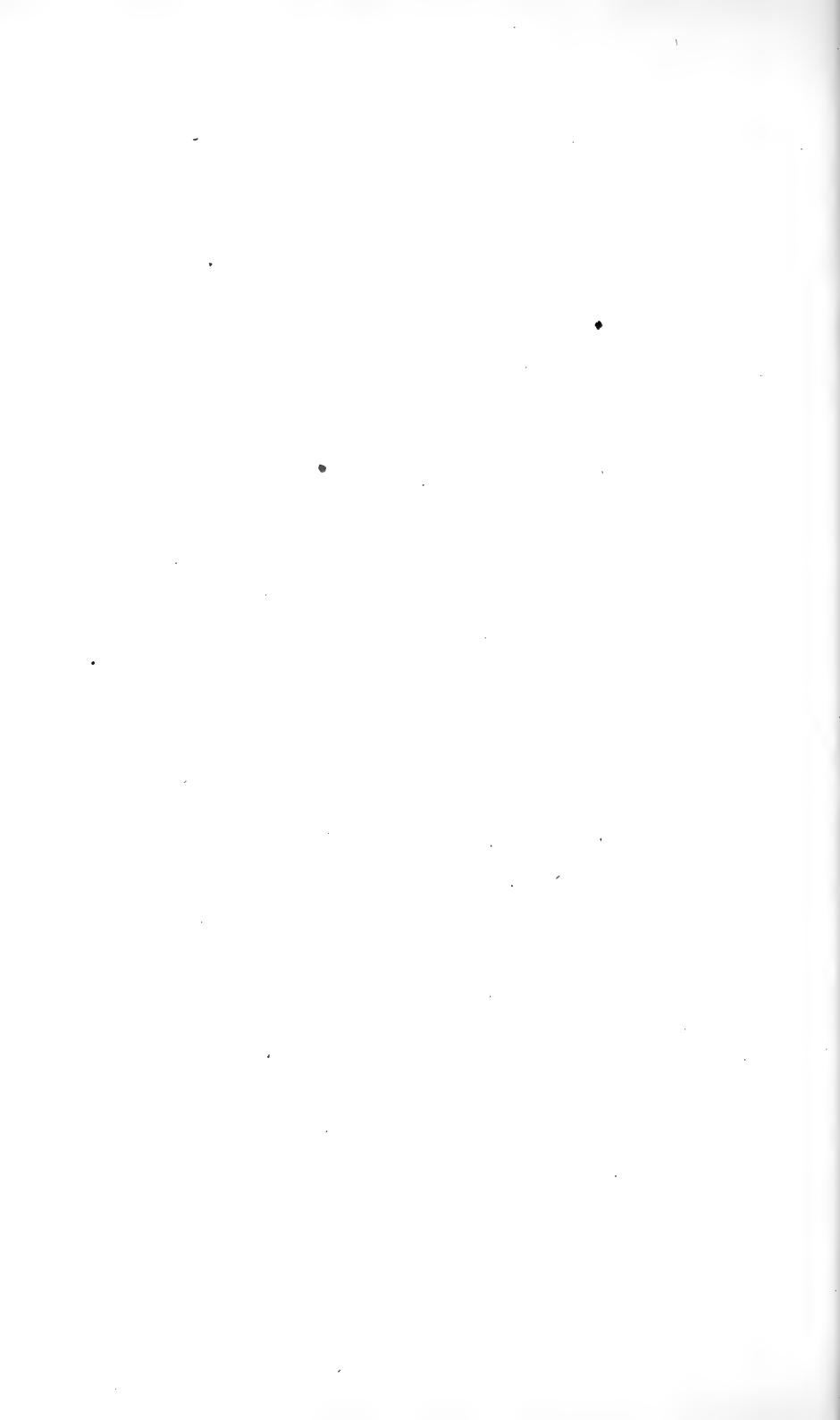
DIRECTOR

FOR

1897-98.

URBANA, ILLINOIS.

1898.



BIENNIAL REPORT
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY.

To the Trustees of the University of Illinois.

GENTLEMEN: In pursuance of your general instructions as contained in your Proceedings for 1892 (June meeting), I submit the following report of operations of the State Laboratory of Natural History for the past two years.

These operations have been connected almost wholly with the work of the State Entomologist or with that of the Biological Station. As the State Entomologist's operations will be reported, under the law, to the Governor previous to the next session of the legislature; I will only say with regard to them here that they have been directed mainly to the study of the life histories of some of the insects injurious to corn, to an examination of the shade trees and other ornamental vegetation of several of the larger towns of central Illinois, and to work on the San José scale, distributed throughout the State.

Further investigation of the corn insects was undertaken with a view to preparing for my next biennial report a second instalment of a monograph upon that subject. The study of the insects injurious to shade trees is the beginning of what I intend to make an exhaustive survey of that topic in this State; and the work on the San José scale has taken the form of a further examination of suspected premises with a view to the possible occurrence of hitherto undetected colonies of that insect in the State, a very thorough and careful spraying with insecticide solution of premises known to harbor the scale, the introduction of two fungus parasites of the scale obtained by me on

a personal visit to Florida last spring, and several lines of experimental work undertaken in the hope of finding some cheaper and more effective insecticide than the one now generally in use. In this same connection I have provided for a general inspection of nurseries throughout the State, made at the expense of the nurserymen. Upon receipt of the report of the condition of these nurseries from my inspectors, I have given to nurserymen official certificates setting forth the facts as to the existence on their premises of insects likely to be conveyed in trade to the injury of their customers.

The operations of the Biological Station have been carried on during the past two years along lines practically the same as those previously reported upon, except that we have done much more during the last two years with fishes than previously, with the expectation of completing a formal report upon the fishes of Illinois on which considerable progress had been made by me long before the opening of the Station.

This study of the fishes of the Station field was taken up systematically in July, 1897, by Prof. Frank Smith, and continued by him without interruption until September 1 of that year. In the summer of 1898 this was passed over to Mr. Wallace Craig, assigned to the Biological Station as its resident naturalist, and he will make this his principal occupation during this entire year. He has been handsomely provided with various kinds of apparatus for the collection of fishes in all the Station situations, including seines of all sorts, fish traps of various size and construction, set nets, and trammel nets. This work is being so conducted as to give us correct ideas not only of the species occurring at the Station, but of their relative abundance and local distribution, their haunts, their habits, their regular migrations and irregular movements, their breeding times and places, their rate of growth, their food, their diseases and their enemies, and, in short, the whole economy of each kind there represented and of the whole assemblage taken together as a community group.

Extensive studies of the aquatic entomology of the situation have also been made, and an elaborate paper on ephemeroptera and dragon-flies, the joint contribution of Messrs. Hart and Adams, of the Laboratory staff, and of Professor J. G. Needham, who

worked with us during a part of the summer of 1897, is now nearly ready for the press.

The so-called plankton work, the systematic study, that is, of the minuter forms of plant and animal life suspended in the water, has gone steadily forward under Dr. Kofoid's immediate care. Refinements and improvements of method, new forms of apparatus, and a vast mass of material which has been largely identified and studied by him are some of the more obvious results of our recent work in this field. No part of the work of the Station attracts more general attention among scientific men or is likely to lead to more interesting and important results.

By the Chemical Department of the University regular analyses of the waters of certain selected localities have been made during the entire two years, including one series of analyses of the gaseous contents of the water, made at Havana, one for each of twenty-four consecutive hours. This chemical work combined with the continuous biological work of the Station will, when generalized, furnish a most substantial and authoritative body of knowledge of the conditions of the waters of the middle Illinois previous to the opening of the Chicago drainage canal which can scarcely fail to have a high utility for comparison with the results of similar studies made after that event.

Our main equipment—the cabin boat, the launch, and the smaller boats—has served our purpose perfectly, and the Station property is in good order and condition in all respects.

The Summer School of 1898, for whose expenses you voted a guarantee fund of \$300, proved a disappointment only in the number in attendance, a deficiency easily accounted for in part by the lateness of the period at which we were able to announce our session, and in part by the fact that we could not offer last year certain local and personal inducements which may easily be provided for another session. Authority to advertise the school was not given until the March meeting of the Board this year, too short an interval thus remaining before our opening in June. For want of any special building of our own we were obliged to resort to the village school building at Havana, generously placed at our disposal without compensation by the school trustees, and students of the School were thus compelled

to live in the town. Vacation life in a village boarding house with work in a school room offers too little relief from the ordinary experience of the student or teacher to be especially attractive in itself. If the School is to be maintained—and I sincerely hope that it may be—we should have a plot of land on the banks of Quiver Lake, two miles and a half above Havana, should have erected there a building suitable for summer use as a students' laboratory, should provide facilities for life in camp to those who prefer them, and should also make it possible for students to live either at that place or in town.

Fifteen students were in attendance throughout our term of four weeks. The only instructors regularly engaged were Assistant Professor Frank Smith, of the Department of Zoölogy, and Instructor C. F. Hottes, of the Department of Botany. The work was carefully planned and very thoroughly and efficiently done, and was received very cordially by all in attendance.

Publication of papers has been made by the State Laboratory to the full limit of our appropriation for this purpose, nine articles of our Laboratory Bulletin, comprising four hundred and thirty-eight pages of text and sixty plates, having been printed and distributed during the last two years. They set forth mainly the general results of our Biological Station work combined with the results of studies by advanced students and the Station staff upon other collections of the State Laboratory, but include also an article on scale insects of the State and one on insect disease. The influence of the State Laboratory upon the Department of Zoölogy is shown by the fact that three of the above papers, each a valuable contribution to science, have been prepared by University students in the course of their work for first and second degrees. Such work would have been entirely beyond their reach except for the materials, equipment, and literature provided by the Laboratory, which has also borne the expense of their publication and illustration.

With respect to the future of this work I am strongly of the opinion that a decided advance should be made in the Natural History Survey, for which the Laboratory is responsible under the law of its establishment. The annual appropriations made of late have been too small to provide for more than the necessary operations of the Entomologist's office, which they are

made to cover, and those of the Biological Station, with some incidental general work naturally growing out of the operations of these two establishments. I see no reason why the State of Illinois should not provide in a suitable manner for the energetic prosecution of this Survey work which it long ago authorized, and I propose, consequently, to ask of the next legislature a suitable sum for this purpose and a separate sum for the economic investigations for which the State Entomologist is responsible. I think, also, that the legislature might well be asked to enlarge the field of the State Laboratory of Natural History to include an economic geological survey, with such topographical work as this might require, and a biological survey of the water supplies of the State, conducted with special reference to sanitary interests, a subject which is certainly not less important in some of its aspects than that of their chemistry.

For details respecting the various departments of the work of the Biological Station you are respectfully referred to the appended reports of the Station Superintendent, Dr. C. A. Kofoid, of Prof. A. W. Palmer, Director of the Chemical Survey, of Mr. Chas. A. Hart, Entomologist of the Station, and of Prof. Frank Smith, who served for a time as its Assistant Zoölogist and as principal instructor in the Summer School.

Respectfully submitted.

S. A. FORBES, *Director.*

REPORT OF THE SUPERINTENDENT OF THE BIOLOGICAL STATION.

To the Director of the Laboratory.

SIR: The past two years have offered new and interesting conditions in the environment in which the work of the Illinois Biological Station has been prosecuted. The period of 1894 and 1895 was one of typical low water, without an extensive rise of the river during the spring and early summer, when such floods usually occur. On the other hand, these years were not marked by long uninterrupted periods of very low water. Under these conditions of two years of generally low water, without marked fluctuations, the lakes were thoroughly choked with vegetation, and even the banks of the river itself became fringed with a rank aquatic growth. A rise to 12.6 feet, culminating January 6, 1896, was succeeded by a series of minor floods at intervals of about two months throughout the year. The net result was an increase in the average height of the river for the year, which was 6.87 feet above low-water mark—fully two feet above that of the average for the two years preceding. This was, then, a high-water year, without marked fluctuations, and the result was that the vegetation remained to a considerable extent in the lakes and the river. The year 1897 opened with rising water, which culminated January 23 at 12.9 feet, while a subsequent rise on March 27 reached a height of sixteen feet—the highest point attained since 1892. (See Plate II.) From this maximum the river fell slowly through the four months that followed, reaching a minimum early in August. From this time until the close of the year, in consequence of a general drought throughout the State, low water persisted, there being only a slight rise as evaporation was checked during the cooler weather of autumn. In spite of the long-continued low water the average height for the year was 6.9 feet—a slight increase over the preceding year. There was thus present the somewhat unusual condition of long-continued high water during the first half of the year followed by an uninterrupted period of unusually low water in the second half, the change from the one to the other being quite abrupt. Under these circumstances the vegetation was largely removed or its excessive growth prevented. The contrast

between high- and low-water conditions in the Station field is well shown by several of the plates appended to this report.* This long-continued low water worked marked changes in the topography of the bottomlands adjacent to Havana. Phelps Lake† dried up earlier than it did the preceding year, Thompson's Lake showed a marked diminution, principally at the northern and southern ends, long stretches of soft mud or matted vegetation in which dead fish were abundant being exposed. This mud, after a few weeks exposure, hardened and cracked open to a depth of a foot or eighteen inches, and a growth of shore grasses began to spring up on it. Quiver Lake, especially along the west shore and in the region known as Dogfish Lake, was considerably reduced in area, and in the absence of any considerable amount of vegetation its depth was decreased more than usual. Flag Lake, which in most years is a marsh with one to four feet of water filled with rushes, arrow leaves, water smartweed, water-lilies, and the lotus, dried up early and a wagon road was established across its bed. Havana Lake, the expanse of the river above the mouth of Spoon River, presented the unusual appearance of a narrow river channel flanked on either side by a broad mud bank. The filling in and extension of these banks by the deposit of silt during recent years has been very marked, and is followed by an extension of the swamp willows over the rising banks.

In a general way the hydrological conditions of 1898 resembled those of 1897. The rise of the river began in January and continued through the winter, culminating April 2 at eighteen feet, a point equaled or exceeded but twice since 1879, at which time records were begun at the Government dam at Copperas Creek, eighteen miles above the location of the Station. As in 1897, the high water continued during the early summer, dropping rapidly in August to the minimum stage. It did not, however, reach the extreme condition of the previous year, several minor fluctuations having occurred at frequent intervals during the fall months. The reduction in the aquatic vegetation begun in the previous year has continued. The increased activity in the fishing industry has also contributed largely to the removal

*For these localities see Plate I.

†Compare Plates III. and IV., and V. and VI. For differences with respect to mid-summer vegetation at similar stage of water, see Plates VII. and VIII.

of the vegetation from the lakes and the river on the fishing grounds, so that the river is now practically free from vegetation, as is also the main body of Quiver Lake and almost the whole of Thompson's Lake, only a restricted area at the southern end retaining its former condition.

In previous years the field headquarters of the Station have been on Quiver Lake, either at Foster's Landing or at the Indian mounds. In the fall of 1896 the new laboratory boat was brought down to town and was stationed at the public landing along the river front. This location has been retained during the last two years with the exception of a week in August, 1898, when the boat was moved up to the Twin Mounds during some continued work upon the plankton and gas analyses in the Illinois River near that point. The advantages of the location at town are the saving of the time required for transit to and from headquarters in the field and the expense of running the launch on these trips, and the ready access to the Station from living quarters at all times, while the distance from the collecting grounds is not greatly increased. Some disadvantages attend this location. The sheltered situation and the close proximity to the sand bluff increase the heat in the boat during the hot days in summer, and the nearness to the steamboat landing greatly increases the risk of damage to the boats and launch by the disturbance in the water caused by incoming and outgoing steamboats. Ropes and cavils are frequently broken, and boats are torn loose by the swells which follow in the wake of the larger steamers. On three separate occasions a steamboat in the hands of an old and experienced pilot collided with our flotilla, resulting in the crushing and sinking of the steam launch in one instance, and in the breakage of glassware aboard the laboratory boat at another time. With the considerable and now increasing number of river craft of all sorts seeking temporary or permanent anchorage on the river front, we have been gradually crowded to the least desirable location, where the shore is somewhat springy, and where at low water access to our boat is possible only by means of a dike of sand or a trestle-work of planking, owing to the soft mud which is rapidly filling in the river front at this point. At such times our location is neither inviting nor salubrious. The crowding of the boats and

the lax care usually given to such property in this locality greatly increase our danger of loss by wreck or fire while we remain in our present location. The experience of the past two years has only emphasized the necessity of the location of the Station at some suitable point — if at Havana, on Quiver Lake — where we can control property which will afford us an abundance of room, freedom from disturbance, facilities for carrying on the shore operations that pertain to our work, and the location of breeding ponds.

The Station was occupied by the Station staff and in full operation in 1897 during the months of July, August, and September, and in 1898 from June 13 to October 1. In addition to this, monthly visits were made to it for plankton work during the winter and spring of 1897, and beginning with the autumn of 1897 visits were made for the same purpose until the full opening of the Station in June, 1898. As a result of these visits a very full series of winter collections has been accumulated. Since September 1, 1898, Mr. Wallace Craig, resident Assistant at the Station, has been in charge during my absence. Previous to this time the property of the Station was cared for at such times by Mr. Miles Newberry, who has been in our employ as general collector, janitor and engineer for the past four years. His service has been efficient and faithful in all the manifold and varied tasks which fall to his hands.

The work of the Station has been in the main prosecuted along the lines established in previous years, with a few expansions in some directions and curtailments in others. The primary purpose of the Station, that of investigation, has been carried on along three principal lines: entomology, ichthyology, and the quantitative investigation of the minute life of the water. The entomological work has been in the hands of Mr. C. A. Hart, who was at the Station during considerable intervals in 1897 and 1898.

Investigation of the fishes was taken up in July, 1897, by Prof. Frank Smith, and was continued by him until September 1 of that year. In the summer of 1898 this work was taken up by Mr. Craig, and additional equipment has been provided. The Station was equipped with a hundred-yard river seine of

an inch-and-a-half mesh, hung to fish eight feet; a forty-yard minnow seine of one-fourth-inch mesh, hung to fish five feet; a thirty-foot minnow seine, hung to fish four feet; a Baird seine of the same dimensions; and a trammel net thirty yards in length and five feet in depth. The additions to the equipment consist of two set nets, one of three-fourths-inch mesh and eighteen-inch hoops, the other of an inch-and-a-half mesh and four-foot hoops. Thirteen fish traps of quarter-inch galvanized wire netting were constructed especially for the work in deep water and in places where a minnow seine could not be used. They consist of a cylinder of netting ten inches in diameter, one end of which is closed by a circle of wood and the other by two successive funnels sloping inward, each with an opening three inches in diameter. For the capture of the smallest fish the nets are covered with fine wire cloth, and their efficiency is also increased by the use of wings of the same material or of minnow netting.

The plankton operations of the last two years have been carried on with increased regularity and greater attention to the correction of possible sources of error. The number of stations subject to regular examination at the beginning of the period covered by this report was seven; viz., the Illinois River two and a half miles above Havana, Quiver Lake, Dogfish Lake, Thompson's Lake, Flag Lake, Phelps Lake, and Spoon River, the latter having been added to the list in August, 1896. (See Plate I.) The Illinois River station was visited at intervals of one month until July, 1896, in which month a number of examinations were made at frequent intervals during a remarkable development of a filamentous diatom, *Melosira*, in the plankton, and in correlation with gas analyses conducted by Professor Palmer. Weekly collections upon Tuesdays were begun August 3, 1896, and have since been maintained except when the condition of the ice or sickness necessitated a slight shifting of the day of collection.

The station in Quiver Lake was visited during intervals of one month during the first half of 1897, but during the latter part of July and the months of August and September the interval was reduced to a week. In October fortnightly visits were commenced, and have since been maintained. In the summer

of 1895 a plankton station had been established in the west arm of Quiver Lake, known as Dogfish Lake. Examinations were continued in this locality for two years at intervals of a month or less, but were discontinued in July, 1897. During much of the year the conditions at this station differed but slightly from those in Quiver Lake. Vegetation is a trifle more abundant and its duration is more extended. Except at times of high water there is no current passing through this arm of the lake. The difficulty of access to this station at times of low water—due to the dense mat of *Ceratophyllum* through which the plankton boat must be rowed—were increased by the erection of a fence of wire netting across the mouth of the lake in the construction of a fish pound. In view of the similarity to Quiver Lake and the difficulty of access, it seemed desirable to drop this station from the regular list, especially as the two years' collections of its micro-flora and micro-fauna will suffice for detailed comparison with the plankton of the main body of the lake.

Monthly plankton collections were made in Thompson's Lake during the first half of 1897, but in July of that year a fortnightly interval was adopted and has since been maintained. This station is, next to the river, the most important one on our list, being located in the largest permanent body of water within the field of our operations. During the period of high water (three to four months of the year), it is of easy access, as it is possible at such times to run the launch through the "cut road" across the bottomlands to the south end of the lake. As the water falls access may still be had for some time with a row boat through the "cut road;" or, at still lower water, through the "swale," a tortuous channel through the bottomland underbrush from the foot of Flag Lake to Thompson's Lake. When, however, the river falls below six feet, the only approach to this station is *via* Thompson's Lake Slough, a bayou connecting the lake with the river, leaving the latter at a point about six miles above Havana. Shallow water and a rank growth of aquatic vegetation found in some years at the northern end of the lake soon render it impossible to enter from the slough with the launch, and when the water falls below three feet a mud bar at the northern end of the slough necessitates making the remainder

of the trip in a row boat. During the months of September, October, and the most of November, 1897, the river stood at the present low-water mark, that is, about two feet by the gauge, and the lake was drained to the lowest limit reached since our operations were commenced at Havana. Its bed at the north end, for a distance of about three quarters of a mile, was exposed, leaving an expanse of the softest black ooze, through which a narrow, winding channel several feet in width, containing several inches of water, was kept open by our boats and those of occasional sportsmen. When winds from the north prevailed, even this insignificant highway was left bare. Under these conditions ingress and egress over and through this bed of ooze became a task of no small difficulty.

Owing to these two routes of approach to the lake, two points of collection have been established; one off Sand Point, in the northern half, and one about half a mile below Prickett's Landing, in the southern half. Both are in open water and at a considerable distance from vegetation, and are equally typical locations. Access to one of these two places is always possible during the period of open water or when the lake is covered with thick ice, but when the ice is thin or rotten, it is at times only possible to work out a few rods from the shore with the aid of ax and ice-hook.

Plankton operations were not carried on in Phelps Lake in 1895, owing to the failure of the river to overflow the bottom-lands sufficiently to invade and fill the lake. During this year a heavy crop of corn was raised in its fertile bed, but before it was harvested the following winter the water asserted its claim to this territory and has since held possession. The rise which culminated January 1, 1896, filled the lake, and the water slowly decreased until November, when the few shallow pools that remained were frozen solid. Water again entered the lake January 6, 1897, and the last pool was dried up about September 1 the same year. Toward the last of February, 1898, rising waters again poured into the lake, and owing to the high water of the past spring continued to occupy it and the adjacent territory until the middle of July. Since that time the depth of the water has decreased rapidly and by the middle of September the lake was reduced to a few large pools. During the first

half of 1896 monthly collections were made, and since that date the interval has been reduced to a fortnight.

During the past year a drainage district has been organized in the territory including and adjacent to Phelps Lake. The object of this organization is the reclamation of the fertile bottom south of Spoon River. A large dike is being built along the north limit of the district, reaching the river a short distance above the north end of Phelps Lake. From this point it passes southward along the river bank for several miles to a point some distance below the mouth of Phelps Lake Slough, and then turns westward to the west bluff. The drainage of the enclosed area will be accomplished by several large ditches leading to the southeast, where pumping works are planned to insure the removal of the water when the surrounding country is flooded. Owing to the drainage of this lake our operations in this locality must cease with the present season, which leaves us in possession of quantitative collections extending through three years, in each of which the water entered in the winter or spring overflow, and was slowly removed by evaporation and seepage throughout the summer months, the catastrophe culminating in the late fall. We have thus in our possession a basis for a tolerably complete record of the seasonal fluctuations and changes in the fauna and flora incident to the drying up of this ephemeral body of water.

Since September, 1896, collections have been made in Spoon River at intervals of a month or less, and during this time a number of qualitative towings have been taken for us by Mr. W. R. Deverman, of Topeka, Ill., from the waters of Quiver Creek. We have thus a good series of collections from tributary streams of the river for a comparison with those of the river itself.

A plankton station was established in September, 1895, in Flag Lake, a large marsh between Thompson's Lake and the Illinois River. Collections have been made here from that time at intervals of a month or less and were continued in 1897 until July. Owing to the abundance of vegetation in Flag Lake this station was extremely difficult of access during the summer months, and owing to the abundance of flocculent debris of vegetation it was at all times difficult to secure a satisfactory

quantitative collection from this body of water. As it was necessary to reduce the amount of field work, it seemed best for these reasons to drop this station permanently from the list of places subject to regular visitation. During the summer of 1898, plankton collections have been made from time to time at the mouth of Flag Lake Slough in the hope of finding here *Trochosphaera*, as in former years. None, however, could be found in this locality or, indeed, in any other in our field of operations during the past summer.

As a rule, the collections made at the plankton stations above enumerated included a vertical one, one from the surface, and one from the bottom water, all made with a pump and a net of No. 20 silk bolting cloth. In addition to these a catch from a liter of water from a vertical sample at each station was made with filter paper, and from five liters with the Berkefeld filter, the first method of filtration being introduced in September, 1896, and the second in November, 1897. The total number of bottles in the regular series for the years 1897 and 1898, each representing a different catch, is 1075.

The collections above mentioned belong to the chronological series whose purpose is to afford a quantitative and qualitative representation of the changes through which the life in the water of the streams and the lakes examined passes during the course of a term of years. In addition to this series a considerable number of other catches have been made with a view to securing data upon certain allied and important phases of the plankton work.

The relation of the dissolved gases of the water to the amount and constitution of the life therein contained is an important problem, and an attempt to collect data has been made in connection with the Chemical Survey of the Waters of the State. In July, 1897, Prof. A. W. Palmer, Director of this Survey, visited the Station and made a number of analyses of the oxygen dissolved in the surface and bottom waters in the lakes and river. In 1898 his visit was repeated, with Mr. R. W. Stark, Assistant on the Survey, and a number of similar analyses were made, the carbon dioxide being also determined. A series of collections extending throughout twenty-four hours was made from the surface and bottom waters of the Illinois

River with a view to determining the diurnal fluctuation in the amount of the dissolved gases. In all these operations parallel collections of the plankton have been made at the same time and from water collected in the same manner, the plankton pump being used for the collection both of the plankton and the water for gas analysis. The twenty-four-hour series collected in 1898 can be brought into correlation with the movements of the water-bloom, which is a marked feature of the plankton of the river during the warmer months of the year. About one hundred bottles are comprised in the collections belonging in this series.

The serial plankton work rests upon the supposition that a single catch made in a typical locality of a lake or river will give a fair sample of the microscopic life of the water, both as to its quantity and constituent organisms. With a view to testing the validity of this supposition, Thompson's, Quiver, and Mantanzas lakes and the river have in previous years been subject to extended examinations, collections being made on the same date at a considerable number of localities at regular intervals throughout the body of water examined. In 1897 Thompson's Lake was reëxamined on this plan and a biological cross-section of the river was made at Havana. This series of collections has been increased by twenty-five bottles during the period covered by this report.

The tests looking toward the detection and correction of sources of error in the plankton method and the justification of changes in it which we have made, have been continued during the past two years. Of the collections made in these tests about one hundred and fifty have been preserved. Tests have been made of the errors resulting from leakage, from the progressive clogging of the drawn net and the consequent variable coefficient, and from the active escape of the larger organisms of the plankton. Several types of funnels for the in-take of the plankton pump have also been devised and tested. Tests of the leakage through the silk and efforts to correct it by some form of micro-filter or precipitation method have also been continued. A variety of filters have been examined, including the Sedgwick-Rafter sand filter, using sharp Berkshire sand according to the

directions of Calkins*, Jackson†, and Whipple‡. The loss by leakage from this filter was so great that we abandoned it and have been using filter paper as a supplementary method of collection since September, 1896, in all regular plankton examinations. For a short time ordinary filter paper was used, but owing to the looseness of its texture and consequent entanglement of the plankton and shedding of lint we rejected this paper and have since used the "hardened filter paper," No. 575, Schleicher & Schüll. The water from which the sample for filtration is taken has been obtained by means of the pump. It was often necessary to take a much larger amount than was used for filtration in order to secure a vertical collection. To obviate this and also to secure greater accuracy in the collection of a vertical sample, a vertical water-trap was devised, which consists of a light brass tube three inches in diameter and eight feet long, at whose lower end is a sliding brass gate by which the bottom of the tube can be closed after it is lowered to the desired depth.

Although the filter-paper collections served to correct the loss by leakage in an important degree, the method was defective in that a small portion of the catch, varying with the amount and character of the plankton, remained on the filter paper, entangled in the fibers of its surface. To obviate this difficulty and to secure, if possible, a method which would be effective and permit the handling of a large quantity of water, experiments were made with the centrifuge. The small machine described in the last report and adopted by us for use in the measurement of plankton collections was found to precipitate a large per cent. of the organisms present in the water, accordingly a larger machine was devised and built at the Mechanical Shops of the University for this purpose (see Plate X.) It consisted of a hollow cylinder axis of gun-metal with two returning arms, each bearing at the elbow a detachable receptacle which receives the solid matter precipitated from the water, which last is passed through the revolving axis and out to the

*Calkins, G. N.—The Microscopical Examination of Water. Rep. Mass. State Board of Health, 1891, pp. 396-421. 2 folding tables.

†Jackson, D. D.—An Improvement in the Sedgwick-Rafter Method for the Microscopical Examination of Water. Tech. Quart, Vol. ix., pp. 271-274. 1896.

‡Whipple, G. C.—Experience with the Sedgwick-Rafter Method at the Biological Laboratory of the Boston Water Works. Ibid., pp. 275-279. 1896.

tips of the elbows before it returns to the axis for discharge at the lower end. This machine is geared to give, with power, 8,000 revolutions per minute. When fitted with cranks for two men, four to five thousand revolutions can be obtained. This apparatus was tested with water from the river at a time when it was full of water bloom,—formed principally of *Carteria*,—and also with water from the lakes in varying kinds and amounts of plankton. It proved to be more effective in the removal of the plankton than any method previously tried, but the operation of the machine by hand was extremely laborious, and the precipitation of the plankton was very slow. Furthermore, a variable and oftentimes considerable amount of the plankton—especially that found in the water-bloom—is at times lighter than the water, and thus cannot be removed by centrifugal force with the heavier constituents.

In November, 1897, a Berkefeld army filter (system Bruckner) was added to the plankton equipment. It is very efficient in removing all the solid matter from the water, and its operation with ordinary samples is quite rapid. It consists of a force-pump and a cylinder of diatomaceous earth, upon which the plankton and silt contained in the water are collected. This is removed by washing with a brush, but in the process a part of the substance of the cylinder is brushed off. This debris is added to the silt of the water and renders subsequent microscopic examination more difficult. The brushing is also disastrous to some of the more delicate organisms, but leaves by far the greater part of the minute forms which escape the silt intact and in suitable condition for enumeration.

During the past two years some progress has been made with an examination, measurement, and enumeration of the plankton of the regular series, though much of the time has been given to the preparation of plankton apparatus and the improvement of the method. In this work the examination of the test collections by the enumeration method has been particularly time-consuming. The work of enumeration has been facilitated by the use of a set of six counting machines, which enable the observer to keep a record of six different species at once without the mental effort of carrying the count in the mind. An extended amount of this work remains to be done before we

shall utilize to any considerable extent the collections now accumulated. This work will be necessary to the full confirmation of the results of our investigation, and will also be very valuable in suggesting new fields for development, especially along experimental lines. The present provision for this work is quite inadequate to a prompt return for our present investment in this department of the operations of the Station. The enumeration of the smaller organisms, especially under the higher powers of the microscope, is particularly taxing upon the eyes, and long-continued application is a severe strain upon the nerves of the plankton statistician. I believe it to be possible by the expenditure of a small amount of money to secure student aid for some of this work in such a way as to render promptly available a considerable portion of the now latent results of our plankton work.

The sanitary analyses of the water in connection with the Chemical Survey of the Waters of the State have been continued. Weekly samples have been collected through the two years from the Illinois River and from Spoon River on days when plankton examinations have been made. Similar regular collections were commenced in Thompson's and Quiver Lakes in September and October of 1897, and have been continued in connection with the fortnightly plankton work. The total number of samples for sanitary analyses collected at the Station and shipped to Champaign during the two years is two hundred and eighty. As these analyses include the determination of the free and albuminoid ammonia, the nitrites and nitrates, the chlorine, and the oxygen consumed, they will furnish data of great value for a comparison with those derived from the plankton work.

The shipment of samples to Champaign for an analysis of the gases dissolved in the water was begun July 23, 1897, samples being sent from the surface water of the river for the determination of the oxygen. In August fortnightly surface samples from Thompson's and Quiver lakes were added to the shipments, and in November additional samples were sent from each of these localities for an analysis of the carbon dioxide. With the beginning of 1898 samples were collected from both the surface and the bottom waters of the three localities above

mentioned for the determination of both the oxygen and the carbon dioxide. This involves the collection and shipment of eight bottles of water from each of the three stations—a total of about nine hundred and fifty samples being shipped in 1897 and 1898. The water was collected with the plankton pump by means of a small pet cock inserted in the discharge pipe. A rubber tube is fastened upon this and inserted in the bottle and water sufficient to fill the bottle three times is pumped through it. The bottle is then closed, the sample being collected with a minimum contact with the air. If the change in the water between the time of collection and the time of analysis does not vitiate the results, we shall find these gas determinations of great importance in the discussion of the plankton data.

The equipment has been maintained in first-class condition so far as the wear and tear of property subject to the vicissitudes of an aquatic environment will permit. The hull of the laboratory boat has been provided with salt shelves and its bottom thoroughly salted to insure its preservation. The decks and guards have been painted repeatedly, and the canvas roof has received a heavy coat of paint. The floors have also been treated with several coats of oil. Three years' experience in our floating laboratory has only increased our satisfaction with its fitness and convenience for the work of a biological station.

The steam launch, with the new equipment of machinery described in the last report, has been of great service. A few repairs have been made from time to time upon the engine, and the boiler and stack have been provided with a shield to decrease heat in the launch. New tubes have also been placed in the boiler. In 1897 the steamer "Josie Sivley" collided with the "Illini" while she was at anchor on the river front, and crushing her against the guard of the laboratory boat opened a seam upon the larboard side and broke several ribs and a stanchion. The launch sunk in shoal water and was easily raised, the damage being subsequently thoroughly repaired. In the spring of 1897 Mr. Newberry secured an engineer's license, and has since cared for the launch.

During the session of the Summer School the carrying capacity of the launch is severely taxed in providing transit for

the field excursions of the classes. At no time is the speed very great, seven miles an hour being the maximum maintained. Furthermore, the draught of the boat interferes with its greatest usefulness in the shoal waters in which at times our work compels us to go. It is only a question of time when extensive repairs will be necessary upon the hull. I would therefore recommend that an effort be made to secure a larger boat with more powerful machinery so as to carry more passengers and, if necessary, to tow a barge. Greater speed and less draught can be secured with such a boat. It would also enable us to considerably extend the field of our operations. Such a launch will be a prime necessity when the work of the Station is extended to the Mississippi River.

The outfit of small boats, which consists of two lap-streak lake-boats, one lap-streak river-boat, and an Illinois River skiff, has been supplemented by the addition of a large flat-bottom seine boat twenty feet in length with five-foot beam for the plankton work. The increasing complexity of this work and the variety of apparatus necessary for its performance has made the load required for a plankton trip too cumbersome for an ordinary boat. The total weight of the boat when manned and loaded with the outfit and water samples is not less than a thousand pounds. The increased attention given to winter work has necessitated the adaptation of the boat to the exigencies of that season. The bow and sides are protected by a sheath of zinc, and while the ice prevails the bottom is shod with two steel runners. With the boat thus equipped it is usually possible by rocking the boat and skillful manipulation of the ice-hooks to beat a way through the thin and rotten ice which will not carry the weight of the load, while the runners allow the boat to slide easily over the surface of the smooth ice wherever this is strong enough to bear the weight. The greatest difficulty attending transit in the field in the winter occurs at times when the river is low and access to Thompson's Lake must be had by portage across the bottomlands at the southern end of the lake. A pair of wheels has been rigged up for this work, but in wet weather or after heavy snows they are hardly adequate to the task.

In the fall of 1896 the rented quarters which the Station

had occupied in town were given up, and the property there accumulated was placed on board the laboratory boat. When the Station was opened the following summer it was necessary to secure storage elsewhere for property of a bulky nature or that for which there was only occasional use, and by the courtesy of the Illinois State Fish Commission we utilized a corner of their warehouse on the river front until the burning of the building in September. We suffered no loss of consequence, and our property, some of it in a damaged condition, was then returned to the laboratory boat for the winter. In 1898 the problem of storage was temporarily solved by the purchase of a cheaply constructed cabin boat twelve by twenty feet.

Although no formal opening of the Station to students was made during the summer of 1897 and no advertisements of its facilities was undertaken, a few applicants for places were accommodated under the conditions attending the opening of the Station to such persons in previous years. The following is a list of those in attendance and the lines of work pursued.

H. C. Beardslee, A. B., Instructor in Science, University School, Cleveland, Ohio. Fleshy fungi and Mycetozoa.

Miss Bertha V. H. Forbes, B. S., Teacher of Biology, High School, Austin, Ill. General biology.

H. M. Kelly, A. M., Professor of Biology, Cornell College, Mt. Vernon, Iowa. Trematoda parasitic in Unionidæ.

S. D. Magers, B. S., Principal of High School, Houston, Texas. Algæ and general biology.

H. L. Roberts, Superintendent of Schools and Principal of High School, Farmington, Ill. General biology.

The following year a Summer School of Biology, with regular courses in botany and zoölogy and offerings of advanced work in zoölogy was planned, and authorized at the March meeting of the Board of Trustees. The school was well advertised in the educational journals, and preliminary and final circulars were distributed as far as possible among the teachers of the State. Extended advertising in the neighboring states was not attempted. The Station staff was mainly responsible for packing and shipping the equipment sent over by the University and the State Laboratory and for its return, for the registration of students, and for the financial management of the school. No

effort was spared to make the equipment of the Station of use to the school. The Board of Education of Havana placed the High School Building at our disposal for the Summer School, and the Teachers' Institute in session during the opening days was transferred to one of the churches by the County Superintendent, Mr. M. Bolan.

The following is a list of the persons in attendance and their present positions.

Miss Anna L. Baldwin, Science Teacher, High School, Pittsfield, Ill.

T. L. Cook, Superintendent of Schools, Mt. Pulaski, Ill.

Wallace Craig, B. S., Assistant of the Illinois State Laboratory of Natural History, Havana, Ill.

Miss Louise S. Dewey, B. S., Fellow in Physiology, University of Illinois, Urbana, Ill.

C. C. Faust, Superintendent of Schools, Mansfield, Ill.

J. F. Garber, A. B., Instructor in Biology and Mathematics, High School, Houston, Texas.

J. T. Johnson, Teacher of Biology, High School, Galesburg, Ill.

Miss Nellie I. Kofoid, B. S., Science Teacher, High School, De Kalb, Ill.

J. E. Meharry, Student, University of Illinois, Tolono, Ill.

Mrs. Sara E. Pierce, Principal of High School, Havana, Ill.

W. E. Praeger, Student, University of Illinois, Keokuk, Ia.

L. H. Pratt, Teacher, Clear Creek, Ill.

F. W. Schacht, M. S., Principal of High School, Chicago Heights, Ill.

Otto Widmann, Student, University of Illinois, Old Orchard, Mo.

C. W. Young, B. S., Assistant in Botany, University of Illinois, Urbana, Ill.

The total number enrolled in the School was fifteen. Of these nine are teachers of natural science in this and other states. Three of those in attendance are now connected with the University as assistants or fellows. Nine of the fifteen students of the School have been or are connected with the University, three are now undergraduates, and six have received their diplomas, two of them remaining as graduate students. This Summer School of Biology might be made a very efficient

means of attracting attention to the facilities which the University offers for instruction in the sciences, since students availing themselves of the opportunities of the Summer School are apt to be drawn to the University for further work.

Although the number in attendance was not so large as had been expected, still certain features of the enterprise are encouraging. Among these is the cordial response of the citizens of Havana to those needs of the School which can be supplied only by local support. There was no difficulty in securing pleasant and comfortable accommodations for all in attendance; and a much larger number would not have exhausted the facilities offered. From its beginning the Station has received generous treatment at the hands of the business men of the town. Indeed, the granting of a site for a Station building upon the public river front on the bluff overlooking the river has been urged in the local press. A second encouraging feature is the satisfaction expressed by those in attendance with the work they have been able to accomplish in Havana, and the frequently repeated desire to continue it when opportunity offers.

Very respectfully yours,

C. A. KOFOID,

Superintendent of Biological Station.

REPORT ON WATER ANALYSES.

To the Director of the Laboratory.

SIR: During the two years just passed the number of water samples, from the streams and lakes in the vicinity of Havana, Illinois, which were examined by the State Water Survey as conducted by the department of Chemistry of the University, were as follows: Illinois River and Spoon River 102 samples from each, these being regular weekly collections from each of these sources. The collections from Quiver Lake number, all told, 28, and a like number has been taken from Thompson's Lake. The waters from these different sources have been subjected to the regular sanitary analysis and there has been in the different seasons of the year considerable variation in the quantities of organic matters contained, but it is to be noted that

the quantities of organic matters in the water of the Illinois River and in the lakes adjacent thereto are ordinarily very high even for surface waters. During the last twelve months the average in the river and also in the lakes shows that the quantity of sewage contained has been considerably less than it was during the preceding twelve months, due of course to the fact that there have been repeated periods of high water and a more generally distributed rainfall during the year of '97-'98 than was the case during '96-'97.

Attempts have also been made during the last year to determine the quantity of dissolved oxygen and of dissolved or free carbonic acid gas in the waters of the Illinois River and the lakes at Havana. We have met with considerable difficulty in making these determinations because of the necessity of doing most of the work here at Champaign. The conditions are particularly unfavorable for work at a distance because of the large quantities of organic matters contained in the water, and, further, because these matters are in a state of putrefactive change, that is, are undergoing somewhat rapid decomposition. The determinations of dissolved oxygen, consequently, commonly give us figures somewhat too low. Tests made on the spot at the time of collection show that the quantity of dissolved oxygen is ordinarily diminished very quickly on standing a few hours, particularly when the vessels containing the water are exposed to the light. Our results, however, have been obtained under practically similar conditions throughout the season and they show considerable variation, at times the quantity of dissolved oxygen being exceedingly low, while at other times the quantity reached the approximate maximum figure. This is true not only of water contained in the river, but also of the water of the lakes. The data which we have in hand has not yet been digested and cannot be until the work has been carried on somewhat more extensively. The free carbonic acid,—that is the carbonic acid which exists not in combination with the bases in the water, but as gas merely dissolved in the water—varies yet more greatly than does the dissolved oxygen. At times there seems to be none present; at other times the quantity present is quite considerable; but these determinations are even more greatly influenced by permitting the samples to

stand, or by the time which elapses during their transportation to the laboratory, and we cannot at present attach very great importance to the results which have hitherto been obtained.

We expect soon to be able to extract gases from water by means of an air pump and then we shall be in a position to obtain results which will not be influenced by the conditions mentioned above, and, provided we shall be able to have collections carefully made at Havana, the work can very easily be continued and completed here at the University.

Since early in the summer of 1897 we have made regular determinations of dissolved oxygen and of carbon dioxide in samples taken from the Illinois River and from Thompson and Quiver lakes, but the earlier results are less reliable than those obtained during the last six months, and these later results are themselves not sufficiently reliable to be made at present the basis of any general conclusions.

Yours very respectfully,

ARTHUR W. PALMER,

Professor of Chemistry.

REPORT OF THE ENTOMOLOGICAL ASSISTANT.

To the Director of the Laboratory.

SIR: During the season of 1897 I was in the field, primarily for entomological observation and collection, from June 29 to August 13, giving attention particularly to the gathering of information and material for use in completing our work on *Odonata* and *Mollusca*. In 1898 two visits to the field were made for work on *Odonata*, *Ephemera*, and *Mollusca*; a week in spring, from April 19 to 25, and two weeks in midsummer, from June 21 to July 7.

The accumulations of material and notes were already sufficiently large for group studies at the beginning of the two-year period covered by this report. Every opportunity has been taken to make desirable additions to them, and they now stand as a superb basis for the study of any group of aquatic forms. The material is all arranged by orders, and consists of about 4,250 vials and bottles of specimens.

There are now in various stages of preparation four papers,

mainly on the entomology of the Biological Station field, one each on the *Odonata*, the *Ephemera*, the fresh-water *Mollusca*, and the aquatic *Coleoptera*. The order of procedure which I have endeavored to pursue in the preparation of these papers, and which seems to lead to the most satisfactory and accurate results, is as follows: First, the collection of a large quantity of material and data under the greatest possible variety of conditions as to locality, surroundings, stage of water, season and time of day; then the careful study of these, in connection with the literature, and the making of copious notes and sketches preliminary to the preparation of manuscript, all evident deficiencies either in material or data being carefully noted down; next, a return to the field at the times and places indicated by the previous collections for the special purpose of supplying, as far as possible, these deficiencies, and finally, after further study of the literature, the writing of the manuscript.

In the preparation of the paper on the *Odonata* I have had the valued assistance of Prof. J. G. Needham and Mr. C. C. Adams, who have furnished the systematic work on the nymphs and adults respectively, while it has been my part to discuss the biology and æcology of the group and of its species and to combine the several manuscripts into a single paper—now nearly ready for the press. Under Mr. Adams's supervision the State Laboratory Artist, Miss Hart, has prepared a valuable series of 134 drawings illustrating the abdominal structures of nearly all our Illinois species, and a series of general drawings of the nymphs and their distinguishing structures is well under way.

For the article on the *Ephemera*, the Station collections and notes have all been examined and the results are nearly ready to be put into manuscript form. It would add greatly to the usefulness of the paper, however, if a study of the large series of nymphs of this order in the general collections of the State Laboratory could be made before the article is completed.

Much time and labor have been spent on the *Mollusca* in the endeavor to place the study of this group on a truly scientific basis. Not merely the shell, but all parts of the animal were studied, full use being made of the unusual facilities at the

Station for work of this kind. The univalves of the Station collection have been determined by Mr. H. A. Pilsbry, of the University of Pennsylvania, and the *Sphaerium* and *Pisidium* by Dr. V. Sterki. More time could profitably be spent on the biology of the *Unionide*, but otherwise the notes are ready to go into manuscript form.

The collections of water beetles have been exhaustively studied and determined, but the systematic examination of the immature stages has not yet been reached.

Respectfully submitted,

C. A. HART,
Entomological Assistant.

REPORT ON THE SUMMER SCHOOL OF 1898.

To the Director of the Laboratory.

SIR: Of the fifteen persons in regular attendance at the Summer School twelve were either teachers, or preparing to teach, in our public schools. Five of them had received training in the laboratories of the University of Illinois, but nearly all of them were without any considerable experience in field-work or in the methods of collecting and preserving aquatic organisms. On this account especial prominence was given to tri-weekly excursions for collecting and field observation, and these furnished probably the most important elements in the work of the session. With the steam launch, row boats, and needful collecting equipment of the Biological Station the entire party made trips to Matanzas, Thompson's, and other lakes within reach of Havana. The use of the Station launch made the excursions highly enjoyable, and by reducing to a minimum the time *en route* gave the party ample opportunity for observing, collecting, and preserving such animals and plants as would best repay further study, or would be useful in the laboratories or museums of the high schools in which the various teachers present were interested. The work done in the laboratory by the several members of the School was largely determined by their past experience and the application to be made of the knowledge acquired.

Soon after the opening of the session it became evident that the needs of the students would be best met by dividing their

time equally between zoölogy and botany; the forenoons were accordingly given to the former, and the afternoons to the latter.

In the department of zoölogy emphasis was given to the lines of work most useful to teachers. Material collected on excursions was used in various ways. For correct methods of dissection as well as a better knowledge of anatomical details some work in dissection was done. Time was also given to acquiring the best methods of preserving specimens of various kinds of animals, as *Hydra*, worms of various groups, mollusks, *Crustacea*, insects,—both larval and mature,—and fishes. The identification of annelid worms, insects, mollusks, and fishes received due attention, and was aided by named collections belonging to the State Laboratory, and also by literature and by a number of synoptic keys to these groups prepared by members of the State Laboratory staff. As a result of this part of the work, teachers were enabled to take home with them properly preserved and named collections of various kinds of animals. All persons not already familiar with the ordinary methods of section-cutting and the making of permanent microscopic preparations had practice in such work.

The work in botany consisted of as thorough a study of the aquatic and terrestrial flora of the surrounding region as the time would allow. The algæ of the Illinois River and connected waters were studied with special reference to their morphology and reproduction. The relation between land and water plants both as to their differences in morphology and distribution was observed and discussed on the field trips.

The phanerogams of the vicinity were treated with special reference to their adaptation for protection and cross-fertilization. Instruction in the methods of the collection and preservation of herbarium material was given to those who desired it. The systematic work on the higher plants was in the nature of a study of the characteristics of orders from different representatives rather than by following an artificial key.

General plant physiology was illustrated by demonstrations with apparatus such as can be employed in laboratories of limited equipment. In the field special attention was paid to the movements of plant parts as influenced by light, temperature, and progress in seed-development. Time at the end of the

month was devoted to a discussion of the matter presented and its adaptation to the needs of the secondary schools, with which most of those present were connected.

Each student was provided with a first-class compound microscope for use in both botany and zoölogy, and had also the use of a microtome and an abundance of apparatus, reagents, and general laboratory equipment from the zoölogical, botanical, and entomological laboratories of the University. An abundance of literature for general reading as well as for work on special groups was provided from the libraries of the University and the State Laboratory.

The instruction in field and laboratory was supplemented by lectures on special forms and groups of animals, and by others, of general biological interest, on cell division, development, parasitism, cross-fertilization of plants, adaptive modifications for protection, etc.

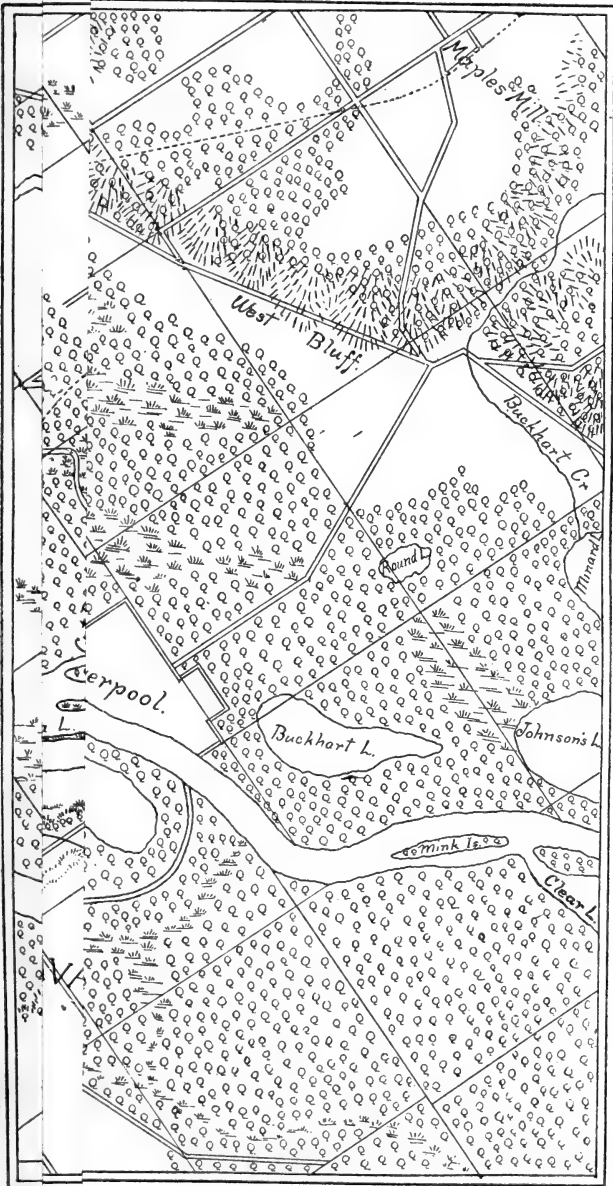
Very respectfully yours,

FRANK SMITH,
Assistant Professor of Zoölogy.



CAI

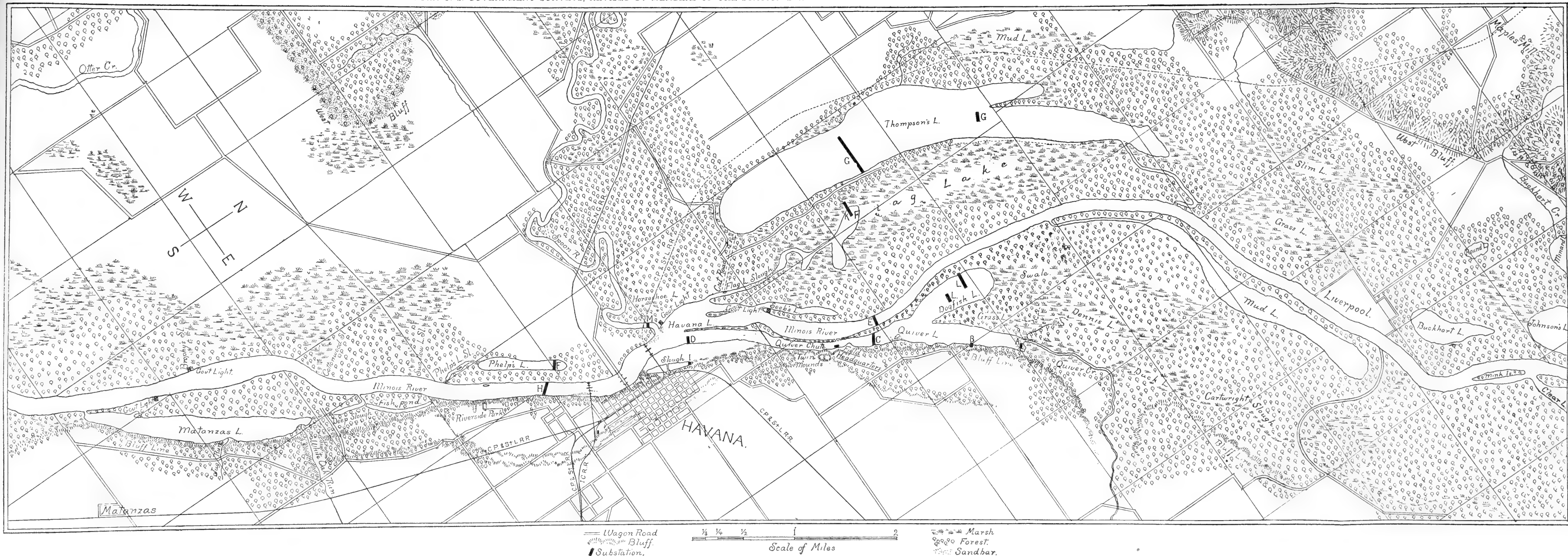
OF



FIELD OF BIOLOGICAL STATION OPERATIONS. LOW WATER.

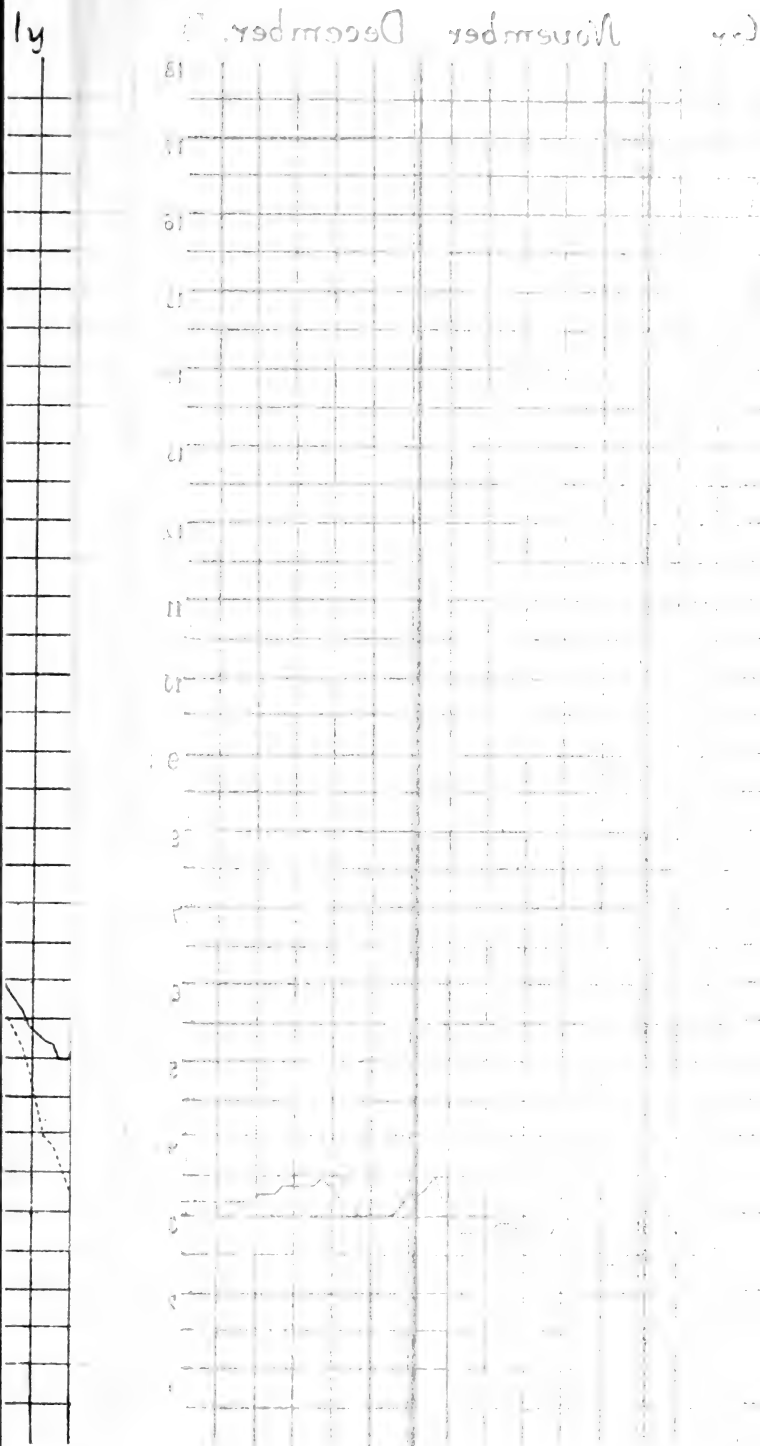
AFTER U. S. GOVERNMENT SURVEYS, REVISED BY MEMBERS OF THE STATION STAFF.

DRAWN BY LYDIA M. HART.

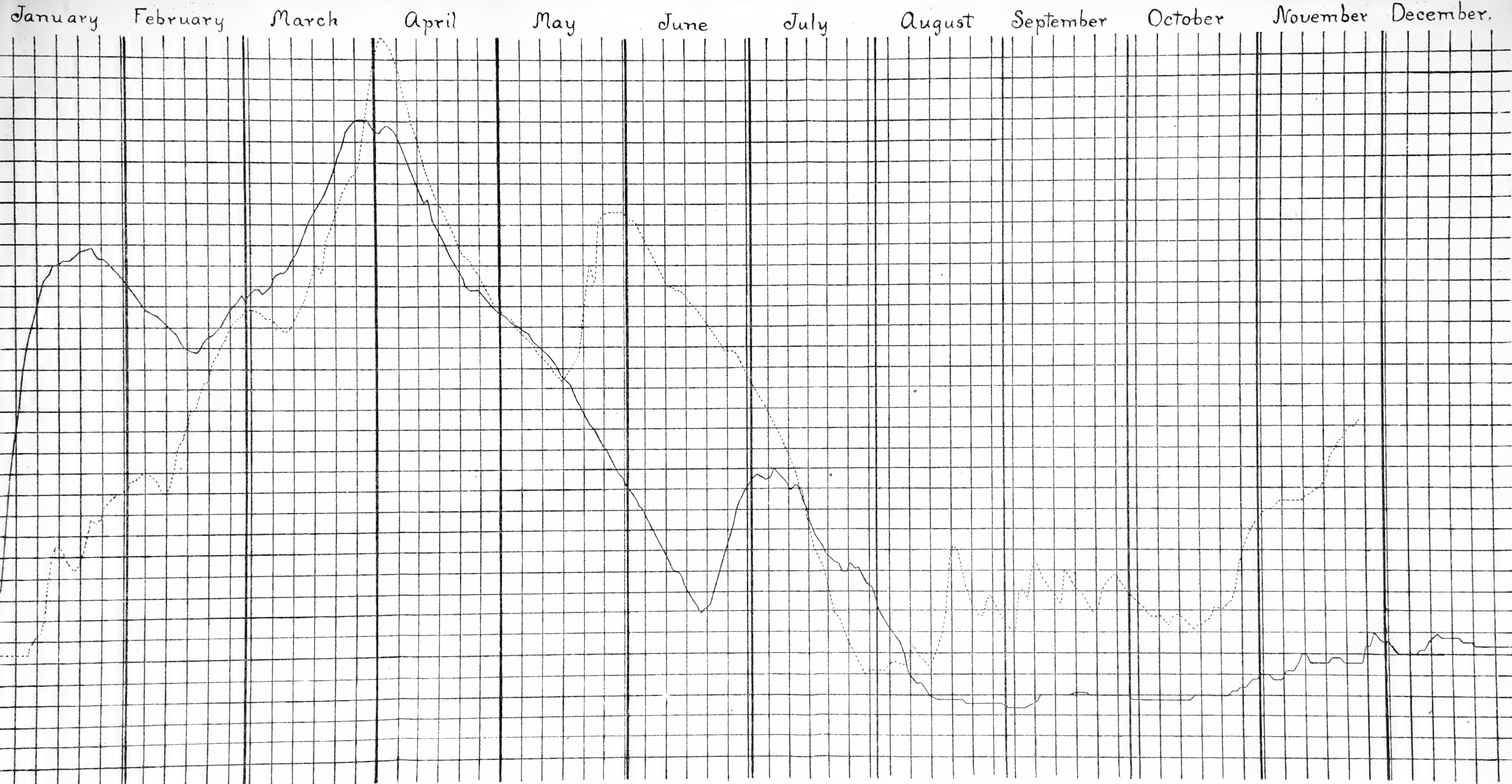


November December

1911



Barney



River Gauge, Havana, Ill. '97 & '98. Basis of Reference is Low Water Mark.



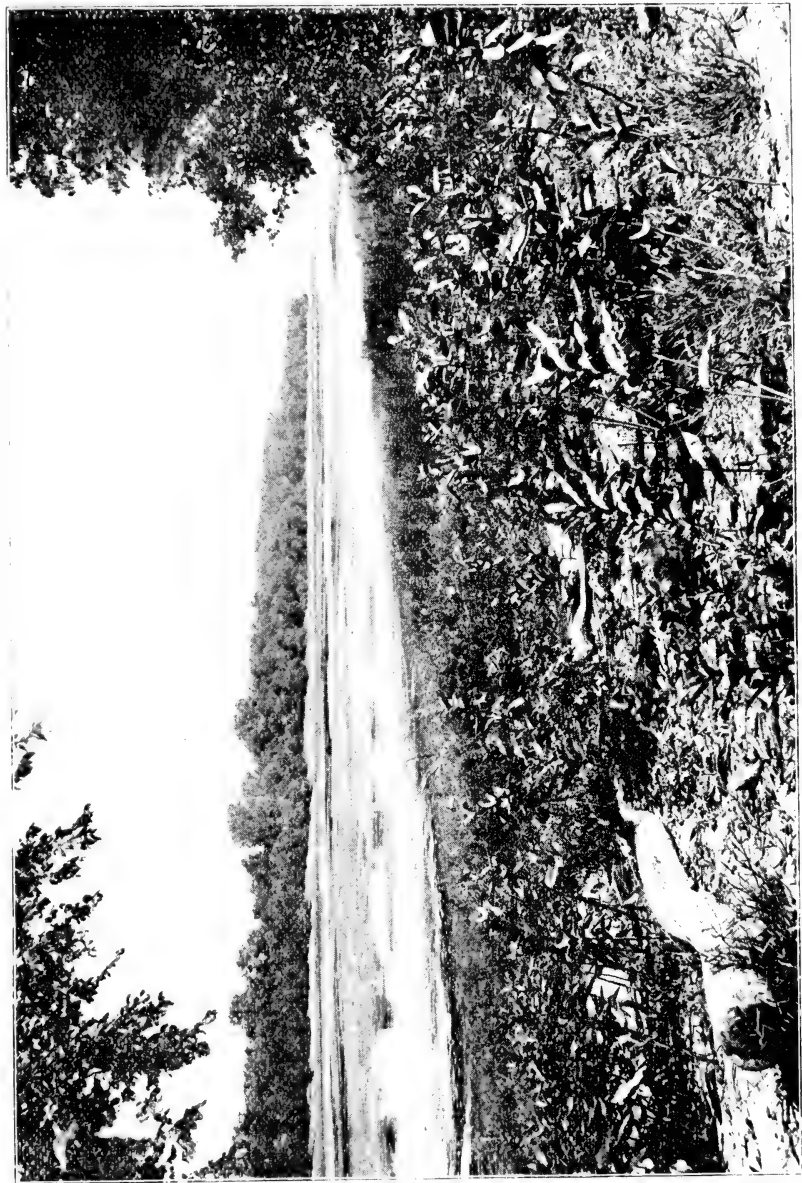
QUIVER LAKE, ILLINOIS RIVER, AND THE ILLINOIS BOTTOMS, LOW WATER.



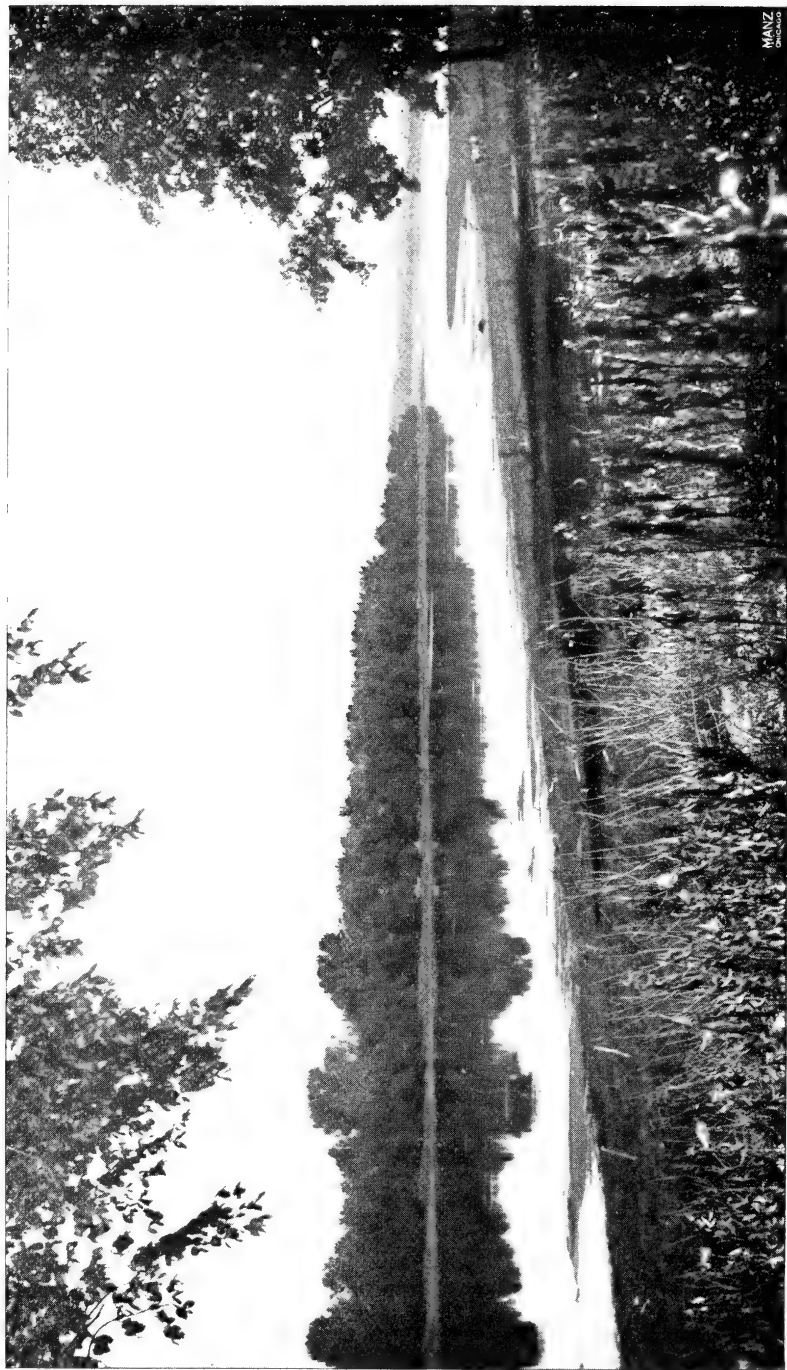


UP THE RIVER, FROM FOOT OF QUIVER LAKE, LOW WATER.





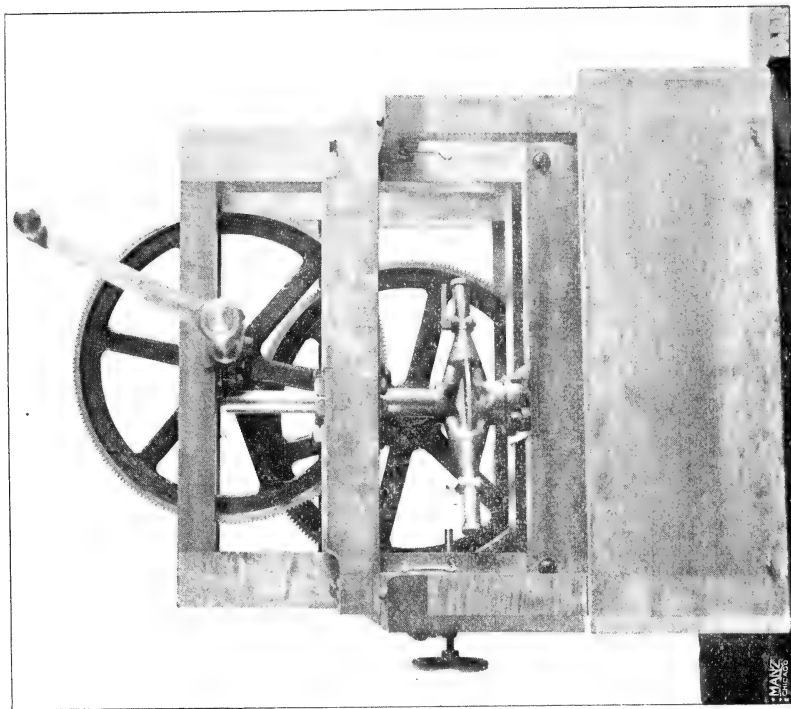
QUIVER LAKE, WITH VEGETATION.



QUIVER LAKE, WITHOUT VEGETATION.



DOWN THE RIVER FROM STATION C.



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ILLINOIS STATE LABORATORY OF NATURAL HISTORY

S. A. FORBES, DIRECTOR.

BIENNIAL REPORT

OF THE

DIRECTOR

FOR

1899-00.

URBANA, ILLINOIS.

1901.

ILLINOIS STATE LABORATORY OF NATURAL HISTORY

S. A. FORBES, DIRECTOR.

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1901.



BIENNIAL REPORT
OF THE
ILLINOIS STATE LABORATORY
OF
NATURAL HISTORY.

To the Trustees of the University of Illinois:—

The work of the State Laboratory of Natural History has been during the past two years mainly a continuation of the Natural History Survey of the State required of it by law. Its field operations have been conducted mainly from the Illinois Biological Station as a center, and have been limited to the aquatic zoölogy and botany of the State.

STUDY OF ILLINOIS FISHES.

A systematic study of Illinois fishes was resumed last year, and has since been carried on as the principal interest of the Survey, and by methods in some respects new. This work is directed towards the conclusion of an elaborate report upon the fishes of Illinois which I have for some years had in hand, and a considerable part of the manuscript for which is already prepared.

Mr. Wallace Craig occupied the Biological Station at Havana as Ichthyological Assistant for eight months—from August 18, 1898, to April 27, 1899. It was his task to study the species of fish occurring in the Station field, their relative abundance, their distribution, migrations and other movements, their times and places of breeding, their feeding habits and food preferences, and the relations of these facts to the conditions of their life in the various waters studied. So far as possible, additional information was also collected as to

special breeding habits, variations in color, and the rate of growth of the different species at different times of the year.

As an equipment for this work I provided a number of fish-traps and set-nets of uniform size and character. The traps were made of galvanized-wire cloth, in the form of a cylinder, about a foot in diameter and four feet long, one end being closed, and the other fitted with two funnels with the small ends pointing inward as in an ordinary fyke-net. The set of fyke-nets were such as are commonly used by Illinois fishermen and were made in two principal sizes; one, of quarter-inch mesh, with a body two feet in diameter and wings spreading about four feet, and the other, of two-inch mesh, with a body four feet across and the spread of the wings about eight feet. In connection with these nets a seine forty yards long and six feet deep, with a quarter-inch mesh, was frequently used.

With this apparatus, parallel catches of fish at a number of carefully chosen stations were made at regular intervals throughout the entire period, the fishes caught were identified, the specimens were counted for each species in each catch, and the data thus obtained were used as the materials of a statistical study of the varying occurrence of the species. This was practically an adaptation to ichthyology of the methods of the plankton biologist. The whole product of the work has been tabulated and studied with a view to general results, and a paper on this subject by Mr. Craig will be in hand for publication some time this winter. Five of the stations were in the Illinois River, one in Spoon River, and three in bottom-land lakes connected with the larger stream. In the Illinois the conditions vary with time and place, but the water is generally muddy, with moderate current. The Spoon River situation was far more variable than the Illinois, but generally the water was muddier and the current swifter. In the lakes, of course, the current is slight and the waters are much more clear. This application of the statistical method of study to ichthyology is already justified by the results of this first attempt, some of which may be thus briefly described:—

The fishes of the Station field may be quite closely divided

into three groups, inhabiting the river, the lakes, and the creeks respectively. These groups are distinguished not by the entire presence or absence of certain species, but by great differences in their relative abundance. By this means the groups are readily distinguishable even where there is a free open-water connection between their habitats. The characteristic species of the river are in general of the lowest organization, the largest, and doubtless the remotest in origin. They range into the Mississippi, and a few still migrate even from the Gulf. The fishes of the lakes are, on the whole, of higher type and smaller size, while those of the creeks are relatively very small and have the highest organization of all. There are also, in the river itself, clear water and muddy water groups, and their local range may change with the shifting of the limiting conditions. For example, when Spoon River is high, making the waters of the west side of the Illinois River near its mouth very muddy, the fishes of that side are different from those of the opposite shore where the water is relatively clear; but when Spoon River is low and the Illinois is equally clear on both sides no such distinction can be recognized. In the spring all these groups are mingled indiscriminately by the great breeding migration up stream into shallow water.

Eighty species of fish were found in or near Havana, the families most characteristic of the region being the catfishes, suckers, and sunfishes. The minnows are more numerous than these families, in species at least, but are comparatively few as compared with other localities. There are also a few very abundant species of other families,—as the gars, dogfish, gizzard-shad, yellow bass, sheepshead, and carp.

Besides this local work on the fishes of the State, two extensive wagon trips have been provided for, one made in the fall of 1899, and the other in progress at this date. Starting from Urbana October 21, Mr. Thomas Large, the Ichthyologist of the Laboratory, went with one assistant and a complete equipment for work in rivers and small streams through eastern Illinois from Ford and Vermilion counties to Vandalia, traversing Douglas, Coles, Moultrie, and Shelby counties, and making extensive collections to represent the autumn fishes of

our prairie streams. Forty-five species were recognized in the basin of the Wabash River, and forty-six in that of the Kaskaskia. Large quantities of material were preserved in formalin for subsequent critical study of species and local varieties. At present a similar party is making equally careful collections from the streams of extreme southern and southwestern Illinois.

A considerable number of collections have also been made by high school principals and science teachers and sent to the Laboratory in aid of this survey. Sets of collecting apparatus and materials for the preservation of fishes were put up at the Laboratory and offered for use to those whom we thought likely to be interested and helpful in this work with the inducement of a named set of the specimens collected, to be returned to the collectors. This proposition was warmly received, and the plan of co-operation has worked to our mutual advantage.

We have thus become indebted for collections of fishes to Supt. C. S. Aldrich, of Canton, to Mr. A. S. Anderson, of Dallas City, Hancock county, to Supt. G. C. Baker, of Hamilton, and to Mr. W. W. Hardin, of Alexis, for collections in Warren and Mercer counties; to Messrs. J. P. Stewart, W. C. Ivins, and C. E. Fort for collections in Henderson county; to Mr. Chancey Juday, now of Madison, Wis., for collections made in White county; to Prof. S. S. Maxwell, of Monmouth College, for a Warren county collection; to J. J. Myers and R. W. Mills, of the University of Illinois, for collections in Henry county and Macon county respectively; to Mr. G. M. Oakman, of La Harpe, for a Hancock county collection; and to W. J. Wible, of Golden, for a collection made in Adams county. We are also under obligations to Prof. W. K. Hill, of Carthage, who spent one month in June and July in examining the streams of Hancock county and making collections from them; to Dr. W. S. Strode, of Lewiston, who sent us the results of a large number of collections from the neighborhood of his town; to Mr. E. M. Wright, of Eureka College, who collected fishes for us in Woodford county, besides giving us much gratuitous service during the summer and fall of 1900; to Mr. R. W.

Braucher and Prof. Charles Oglevee, of Lincoln, for one week's collecting in Logan county; and to Mr. H. L. Roberts for several days' collecting in the neighborhood of Farmington, Fulton county.

CARE OF COLLECTIONS.

Extensive work on the Laboratory collections of fishes accumulated during former years has been done by Dr. Kofoid, assisted by Mr. Large. The accumulations of the last thirty years have been overhauled, and the cataloging, identification, and arrangement of this material has been practically completed. The collections assorted to the present time are contained in sixty-three large copper tanks and in 2,327 jars and bottles. They represent 474 Illinois localities from which collections have been made sufficient to represent the fish fauna fairly well. About six barrels of specimens lately collected at Havana and Meredosia are still to be distributed. These specimens have now been kept for several months quite closely packed in a preservative consisting of ninety-five parts of sixty per cent. alcohol, four parts of glycerine, and one part of formalin. This formula has thus far given excellent results, the form and color of specimens being remarkably well preserved. It has the further advantage that the fishes do not dry up readily when out of the fluid for examination.

A very large work has been done during the last year upon other aquatic material stored in the State Laboratory rooms, especially on collections made some years ago in Yellowstone Park, in Lake Winnebago, Wis., in the Mississippi River and connected waters at Quincy, and in a number of other minor localities.

COLORING PLATES OF FISHES.

A beginning was made this summer in the preparation of colored plates for the report on the fishes of the State now in course of preparation. The Artist of the Laboratory, Miss L. M. Hart, spent a considerable part of the season at the Biological Station, at Meredosia, where an aquarium was maintained with a continuous flow of water to keep fishes alive.

From these color drawings were made, under the constant supervision of Mr. Large, accurate in detail, and true to life in color, form, and attitude. Sixteen such plates were finished during the season. A reproduction of these exquisite drawings by a method in keeping with their quality will call for an appropriation of some thousands of dollars, but will give us a more finished series of plates of American fresh-water fishes than has yet been published. It is my purpose to illustrate every species by such a plate, with black and white figures additional to exhibit technical characters.

STUDY OF THE PLANKTON.

Our systematic study of the minute plant and animal life of the water (commonly called the plankton) was quite fully described in my last report. This work was continued at Havana until interrupted by the removal of the Biological Station to Meredosia in April, 1899. Since that time field work on the plankton has been limited substantially to ordinary collections with a tow-net from the river at Meredosia and in Meredosia Bay and to a series of quantitative collections made during a trip of the steamer of the Illinois Fish Commission from the mouth of the river to Hennepin in May, 1899. This series was intended to give us the materials for a knowledge of the distribution of the plankton in the course of the river at the time. By means of a submerged pipe which delivered water to the net as the boat progressed, collections were made with ten-mile intervals throughout the trip.

Regular plankton work was begun at the Biological Station in June, 1894, and was kept up with no important break to the time of suspension above mentioned, that is, for nearly five years. The vast accumulation of material thus obtained is now undergoing examination by Dr. Kofoid and by assistants under his immediate direction, in the expectation that results in form for publication may be reached early next year. This is by far the largest and most valuable body of work on the minute plant and animal life of a river system which has ever been brought together, and the publication of our full reports upon this subject will contribute in a notable

way to the progress of knowledge in this department of biology.

INSECTS AND LEECHES.

Work on aquatic insects has been more or less systematically pursued by Mr. Hart, and a paper jointly prepared by himself, Prof. J. G. Needham, now of Lake Forest University, and Mr. C. C. Adams, formerly a Laboratory Assistant, is at present being copied for publication.

The Illinois leeches accumulated during several years past have been lately critically studied by Mr. J. Percy Moore, of the University of Pennsylvania, and a paper giving the results of his determinations and embodying also the observations of our collectors is now going through the press as an article in the Laboratory Bulletin.

DISTRIBUTION TO PUBLIC SCHOOLS.

As several years have elapsed since our last distribution of natural history specimens to public schools, during which many thousands of named duplicates have been accumulated, I began last winter preparations for another distribution of surplus material and sent to twenty schools a first instalment of such collections. This instalment consisted of marine and fresh-water specimens in alcohol and formalin, the marine material being mainly that derived from the Aquarium of the U. S. Fish Commission at the close of the Exposition of 1893, and the fresh-water specimens being accumulated in the course of our regular work. From twenty-five to sixty species were included in each collection, representing in each case the important groups of animals. Several months' work of one assistant has been devoted to this distribution and to preparations for a much larger issue of insects and other dried specimens to be finished the coming winter.

PUBLICATIONS.

The publications of the State Laboratory during the last two years comprise nine Bulletin articles, containing two hundred and thirty-eight pages and illustrated by six plates. These articles are purely technical, valuable to students of

their subjects, but of comparatively little immediate educational utility. The ichthyological report, on the other hand, will be prepared with a view to presenting an exhaustive statement of our knowledge concerning the species of fishes of the state from the standpoint of the ichthyologist, but also all the facts and inferences concerning our native fishes of interest to fishermen, science teachers, amateur students, and other intelligent citizens.

The rapidly growing interest in nature study, and the urgent and increasing call for materials available to the science teacher lead me to believe that the State Laboratory may do education a service at this time by giving its periodical publications a new form and direction. While brief technical papers should undoubtedly be published from time to time as new results of merely scientific value are obtained, I intend that our principal Bulletin articles shall be prepared with the needs of the science teacher and the advanced science student especially in mind. One such article is now in course of preparation by Professor Smith and will probably be ready for publication during the course of the winter.

THE LABORATORY LIBRARY.

Increased activity in publication has enabled us during the last two years to establish a larger and much more valuable system of exchanges than heretofore, especially with European scientific societies and institutions. We are now receiving in exchange for our State Laboratory Bulletin one hundred and eighty-one periodical scientific publications, of which fifty-nine are American, twenty-eight are British or British-colonial, twenty-six are German, sixteen French, twelve Italian, and the remaining forty are Russian, Swedish, Norwegian, Danish, Dutch, Hungarian, Portuguese, Egyptian, South American, and Japanese. Purchases for the library, although made to the limit of our actual requirement, have been fewer in number than of recent years owing to the fact that the departments of our work now in progress have been remarkably well provided for heretofore. Purchases of books, pamphlets, and periodicals amount to \$1274.47 for the two

years, and the library additions for this period number 648 volumes and 764 pamphlets.

RESIGNATIONS AND APPOINTMENTS.

Dr. C. A. Kofoid has tendered to me his resignation of his position as assistant in the State Laboratory of Natural History—a position which, in his case, involved the superintendency of the Biological Station and the nominal rank of an assistant professor of zoölogy in the University. This resignation is in consequence of an appointment received by him as Assistant Professor of Zoölogy in the University of California. With the leave until January 1, kindly granted to him on our behalf by the University of California, I can to advantage dispense with a Station Superintendent for the remainder of the present appropriations' period, and I recommend that his resignation be accepted, and that for the present no appointment be made to the vacancy thus created. His withdrawal from active station work has necessitated some redistribution of service among the remaining members of the Laboratory staff, and I have to report for your approval the following list of assignments and salaries for the fiscal year now current: Mr. Thomas Large, Ichthyological Assistant, at eighty-five dollars a month, H. C. Forbes, Business Agent and Librarian, at one hundred dollars a month, and Miss Mary J. Snyder, Secretary, and Miss L. M. Hart, Artist, on the same terms as last year.

STATE ENTOMOLOGIST'S OFFICE.

The account of the operations of the State Laboratory can scarcely be regarded as complete without brief mention at least of the operations of the State Entomologist's Office, closely associated with it. Although the work of this office is legally and financially independent of that of the State Laboratory, it is substantially a branch of the work of the Natural History Survey of the State limited to entomology in the broad sense, and directed mainly to economic ends, but resulting, nevertheless, in very large accumulations of specimens and data which will ultimately be available for the zoölogical reports.

The investigation work of this office during the past two years has been very largely directed to the study of the insects found on sugar beets in Illinois and to those infesting trees, ornamental shrubs, and the other street, park, and garden vegetation of our cities and towns. Our study of the beet insects has been presented in a bulletin of the Agricultural Experiment Station under the form of a monographic account of the economic entomology of the sugar beet for the whole United States.

Respectfully submitted,

S. A. FORBES, *Director*.

September 18, 1900.

UNIVERSITY OF ILLINOIS-URBANA



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